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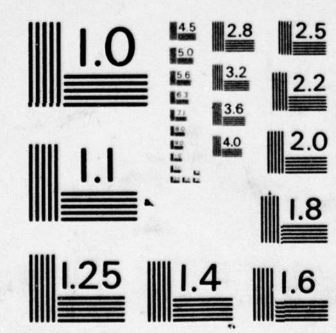

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BOOK I

MODEL USERS' MANUAL FOR AIRFIELD CAPACITY AND DELAY MODELS

Carl T. Ball

November 1976

Final Report

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16. Abstract

The FAA has developed a family of computer models for the analyses of the airside of an airport. These models can be used to determine the capacity and delay on airports, and to study the fine-grain sensitivity of capacity and delay to variations of airport specific conditions.

This model users manual presents detailed instructions for using the FAA capacity and delay models. The manual is written primarily for airport planners and engineers who have a general familiarity with computer operations and who wish to apply these models to airport studies.

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METRIC CONVERSION FACTORS

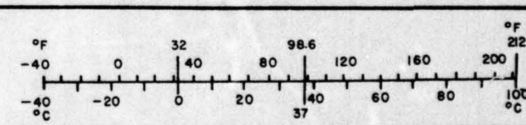
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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PREFACE

This report was prepared by the Systems Research and Development Service of the Federal Aviation Administration as part of its broad research program to develop new and improved methods for determining how to increase capacity and minimize congestion on the airfield.

The purpose of this report is to furnish the aviation community with non-proprietary tools to determine airport capacity and delay. The author would appreciate receiving any comments pertaining to the use of this report.

The material contained in this report is based in part on the joint efforts of a project team headed by Douglas Aircraft Company and included Peat, Marwick, Mitchell & Co. (PMM&Co.); McDonnell Douglas Automation Company (MCAUTO); and American Airlines, Inc. Professor Robert Horonjeff of the University of California, Berkeley, served as general advisor to the project team.

As part of the coordinated efforts of the Project Team each organization carried out specific responsibilities, as summarized below:

ORGANIZATION	Project Responsibility
DAC	Prime Contractor; overall technical direction and project management; data collection support; on-line capacity.
PMM & CO.	Capacity and delay model development; report development; management of data collection and analysis; software review modification and development; training.
McAUTO	Interactive Graphics system and real time simulator feasibility studies; delay model air traffic control algorithm; model software development; data processing; software documentation; training.
AAL	General advisory, overall project.

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EXECUTIVE SUMMARY

General.

The FAA has developed a family of computer models for the analysis of the airside of an airport. These models can be used to determine the capacity and delay on airports, and to study the sensitivity of capacity and delay to variations of airport specific conditions. These models can be used to produce:

Hourly runway, taxiway and gate capacity

Hourly and daily delay, travel times, flow rates, and queueing data

Annual delay and annual capacity

These models fall into two general types; i.e., analytic and simulation. The analytic models consist of a series of equations which compute hourly capacity, annual delay and annual capacity from fixed input parameters. The simulation is a fast time critical event model which emulates the movement of aircraft on an airport using Monte Carlo sampling techniques and produces detailed operational analysis data.

Inputs to these models may be entered in several forms. Some of the models accept input via cards or special input-output devices. Some of the models accept input via "on-line" techniques where the user activates the program from a teletype terminal and inputs data as the program requests it via questions. The Runway Capacity Model has been constructed to accept inputs in either form.

The following is a brief description of the principle models and their required inputs and outputs.

Brief Description of the Capacity Models.

Analytic models were developed to determine the hourly capacity of individual airfield components; i.e., runways, taxiways and gates.

Runway capacity models were developed for over 100 runway use configurations. One model was developed for determining the hourly capacity of a taxiway crossing a runway and another was developed for estimating the capacity of exclusive use gate sets. Each of these models calculate capacity as the inverse of the weighted average service time for all aircraft being served. For example, if it takes an average of 45 seconds for aircraft to be "served" on a runway, then the capacity of the runway equals one aircraft operation per 45 seconds, or 80 operations per hour.

The following information is required to compute the hourly capacity of runways, taxiways and gates:

a. Runway Capacity.

Runway use configuration

Separations between aircraft

Ceiling and visibility

Aircraft mix

Percent Arrivals

Percent touch-and-go operations

Aircraft operating characteristics

b. Taxiway Crossing Capacity.

Taxiway-runway intersection location

Runway operations rate

Percent arrivals on runway

Headway between taxiing aircraft

Runway crossing length

Taxiing velocity

c. Gate Capacity.

Number and type of gates

Gate mixes

Gate occupancy times

The capacity model can be used with minimal preparation time. Input values reflecting national average condition have been determined for many of the input parameters. Airport specific inputs can be coded in a few hours. A typical run might consist of 50 cards and cost $1 to $2. The capacity results can be used in conjunction with delay curves published in the Report No. FAA-RD-74-124, "Techniques for Determining Airport Airside Capacity and Delay," to quickly determine average delay per operation.

Brief Description of the Simulation Model.

The model simulates the movement of aircraft from the entry gate (sometimes the outer marker) of the common approach path to the apron gates, and from the apron gates to takeoff. The model is a critical events model that employs Monte Carlo sampling techniques. Variable time increments are used as the time flow mechanism (i.e.,

clock time is advanced by the amount necessary to cause the next most imminent event to take place). Because of the modular structure of the model, the total airfield or its individual components can be analyzed by manipulation of the model inputs.

a. Principal Input Needed for the Simulation Model. Because the model is applicable to any airfield layout, it is necessary to describe the airfield to the computer as a network of paths that aircraft will follow. This network is developed by dividing the airfield into a series of nodes and links. Principal inputs to the model include:

Aircraft routings

Runway use

Exit taxiway usage

Runway occupancy times for each exit

Distribution for aircraft approach velocities

Distribution for aircraft gate service times

Distribution for separations between aircraft

Air traffic control rules and procedures

Aircraft taxiing velocities by link

Aircraft demand levels and characteristics

b. Principal Outputs Obtained from the Simulation Model.

Total travel times on the airfield for arriving and departing aircraft

Average aircraft delay on each component of the airfield (landing, taxiing, gate, departure queue, etc.)

Total delay experienced on individual links of the airfield

Queue lengths for aircraft waiting to take off

Actual aircraft operations rates (as opposed to desired or scheduled operations rates)

Considerable preparation time is required to use the Simulation Model. The bulk of the input data must be developed for the specific site. Input may require from 500 cards for a general aviation airport to 6000 cards for a large commercial airport. Computer running time for each run is a function of the number of aircraft to be processed, number of random number seeds used and

complexity of the geometry. Typical run costs may vary from $30 to $500. The Delay Simulation Model is suited for the in-depth operational analysis that would be used to make major changes at an airport as opposed to quick first cut analysis available from analytic approaches.

__Brief Description of the Annual Delay Model.__

This analytic model determines annual delay based on the calculation of hourly delay for representative hours of the year. The model aggregates hourly delays into measures of annual delay based on the frequency of occurrence of weather conditions, demand variations and the runways in use.

(a) __Principal inputs required for annual delay calculation:__

Annual demand

Weekly demand as a percent of annual demand

Daily demand as a percent of weekly demand

Hourly demand as a percent of daily demand

Demand profile factor

Hourly runway capacity distribution

(b) __Outputs of the annual delay model:__

Average annual delay per operation

Total annual delay

Distribution of annual delay

The Annual Delay Model can be used with minimal preparation time. Considerable time may be required to accurately determine the site specific demand distribution inputs. Use of the model as opposed to aggregating delay manually will save a large amount of calculation time. A typical model run might consist of 40 cards and cost $15 to $20 as compared to 2 to 3 weeks of manual computations. The annual delay output can be used in cost-benefit analysis or to determine annual capacity based on a level of service.

__Use of This Manual.__

This Model Users Manual is designed to facilitate the understanding and use of the FAA Capacity and Delay models. The manual is written primarily for airport planners and engineers who have a general familiarity with computer operations and who wish to apply these models to airport studies. It is intended that the reader of the manual will be able to use the models with only very limited outside

support. The manual does not provide details necessary for the user to modify the source computer programs.

The first chapter of this manual introduces the user to the concepts and definitions used in the FAA Capacity and Delay models. Each remaining chapter describes the logic, inputs and outputs for one of the FAA models. Five appendices are included in this Model Users Manual which describe optional pre-processor and post-processor models that can be used with the FAA models. Examples are presented throughout the manual which should be carefully examined by the user to help him set up his own problem.

CHAPTER 1 - INTRODUCTION

1.1 Purpose

The Federal Aviation Administration (FAA) has been involved for several years in a broad research program to develop reliable planning tools to evaluate proposed approaches to increasing capacity, minimizing congestion on the airfield, and to quantify changes to the airport airside system. This report introduces the results of an engineering and development project which applied advancements in computer technology and mathematical modeling to the determination of airfield capacity and aircraft delay. The purpose of this report is to describe in detail the preparation of inputs for the computer programs resulting from this project.

1.2 Background and Objectives

A graphical procedure for estimating runway capacity was developed for the FAA in the early 1960's. This procedure defined capacity in terms of an "acceptable" value of delay per operation; i.e., level of service definition of capacity. It did not permit detailed analysis of site specific conditions. Since its development, wide-body aircraft have been placed in service, new aircraft separation rules have evolved and the need to consider more runway use configurations has arisen. These factors coupled with current and anticipated congestion and delays at high-activity airports led to the need for more refined techniques for determining airport capacity and delay.

In June 1972, the FAA retained a project team to develop computer programs for predicting airfield system capacity and aircraft delay. The project team was headed by the Douglas Aircraft Company of the McDonnell Douglas Corporation and included Peat, Marwick, Mitchell & Co. (PMM&Co.); McDonnell Douglas Automation Company (MCAUTO); and, American Airlines, Inc. Professor Robert Horonjeff of the Institute of Transportation and Traffic Engineering (University of California, Berkeley) served as a general advisor to the project team. The objectives of the project team were:

a. To develop validated computer programs for determining airfield capacity and aircraft delay.

b. To prepare a report providing simplified procedures; i.e., curves, tables, etc., for determining hourly capacity and delay as well as annual capacity and delay for use by airport planners in both the FAA and industry.

In support of the project, a comprehensive data collection program was carried out. Some 150,000 items of data were collected at 18 U.S. airports. In addition, extensive data from other sources was used in the analysis. This data base was used to formulate the basic capacity and delay models, and to develop the operational parameters; i.e., arrival-arrival separations, runway occupancy time, approach velocity, etc., used to produce the simplified procedures to calculate airfield capacity and aircraft delay.

In consultation with FAA and industry users, the project team selected a definition of capacity which was independent of aircraft delay. It was determined that capacity defined as the upper limit or maximum number of aircraft operations that can occur would be a more natural and better understood concept. The selected approach to the definition of runway capacity has several advantages. It allows the sponsor/planner to select the level of service; i.e., average delay per operation, for which the airport will be designed (or will be permitted to operate). It also provides a realistic hourly limit to the operations rate for an airport. Recognizing the need to relate demand, capacity and delay in airport planning, the project team developed hourly delay curves which can be used to quickly approximate the average hourly delay per operation associated with airport specific capacity and schedule (i.e., demand and peaking within the hour) characteristics.

Airfield capacity and delay models were developed to analyze site specific airport conditions. They were validated at three high traffic volume airports.

- o Chicago-O'Hare International Airport (ORD)
- o Dallas Love Field (DAL)
- o Orange County Airport, Santa Ana, Ca. (SNA)

The validation process was performed to verify the logic and accuracy of the capacity and delay models. The validation demonstrated that the Capacity Model yielded aircraft flow rates and the Delay Simulation Model yields travel times well within the required contract accuracy of ± 15%.

In pursuing the above project, the FAA had two program objectives:

(1) To update and extend the present Advisory Circulars pertaining to airport capacity and delay.

(2) To develop computer programs to standardize the procedures used for detailed site specific analyses of airport capacity, delay and congestion.

Report FAA-RD-74-124 titled "Techniques for Determining Airport Airside Capacity and Delay," dated June, 1976, fulfilled the first program objective. The instructions provided in this report are a part of the fulfillment of the second.

1.3 Principal Definitions

The principal terms used in this report are:

a. Hourly Runway Capacity. Hourly runway capacity is defined as the maximum number of aircraft operations (i.e., arrivals and departures) that can take place on the runway(s) in an hour under a specified combination of conditions. The hourly runway capacity depends on a number of conditions including, but not limited to, the following:

(1) Runway Use Configuration

(2) Aircraft Mix

(3) Percent Arrival

(4) Percent Touch-and-Go

(5) Operating Conditions (VFR, IFR)

(6) Exit Location and Type

(7) Separation Between Aircraft

(8) Aircraft Operating Characteristics

The capacity values calculated using this report are the maximum flow rates that occur under saturation conditions. Capacity flow rates assume that arrival and/or departure aircraft are always available when needed to fill every operational slot. This situation would normally require that the queue of arrival or departure aircraft be at least one. The capacity flow rates make no arbitrary assumption regarding "acceptable" delay per operation. Delays at capacity flow rates may vary from 2 to 10 or more minutes per operation, depending on the distribution of demand over the hour (i.e., bunching) and the length of time that demand rates are greater than capacity.

For many applications the user will want to determine a runway flow rate that can be sustained for an extended number of hours during the day. In determining a sustainable flow rate, the capacity parameters must be carefully considered. It should not be assumed that an airport would operate at a flow rate equal to hourly capacity for several consecutive hours except under unusual or severe conditions, and then only with major delay problems.

b. Aircraft Delay. Aircraft delay is defined as the difference between the actual time it takes an aircraft to operate on the airport and the normal time it would take the aircraft to operate without interference from other aircraft. Conditions accounted for are:

(1) Inbound Arrival Holds; i.e., the additional flying time required of airborne arrivals due to instantaneous or prolonged periods of overdemand on the final approaches to the runways. Components of this delay are:

(a) Terminal Area Vectoring Delays

(b) Holding Stack Delays

(c) Enroute Path Stretching Delays

(2) Departure Queue Delays; i.e., the time a departure spends waiting for access to the runway whether the airplane is waiting in a queue or is taxiing at reduced velocities while awaiting access.

(3) Taxi-in and Taxi-out Delays; i.e., the time a taxiing aircraft has to wait at a taxiway intersection or is otherwise prevented from moving on a taxiway.

(4) Runway/Taxiway Crossing Delay; i.e., the time spent by a taxiing aircraft while holding to cross an active runway.

(5) Gate Delay; i.e., the time an aircraft has to wait due to a gate not being available or because it is prevented from backing out of its gate due to other taxiing aircraft.

The delay model described in this report does not (normally) account for delays due to enroute congestion, transitioning from one runway use configuration to another, or delays due to airport closures. Delays due to maintenance or construction can be calculated by properly applying the techniques; i.e., selecting the input data.

Aircraft delay is expressed in minutes per operation. The value obtained represents an average or expected value. Delays to individual aircraft may vary substantially from this average.

c. Hourly Capacity of a Taxiway Crossing and Active Runway. The hourly capacity of a taxiway crossing an active runway is defined as the maximum number of aircraft operations that can take place in an hour on a taxiway crossing an active runway under a specified combination of conditions. The runway-taxiway crossing capacity depends on a number of conditions including, but not limited to, the following:

o Taxiway-runway intersection location

o Runway flow rate

o Percent arrivals

o Headway between taxiing aircraft

o Runway crossing length

o Taxiing velocity

d. <u>Hourly Gate Capacity</u>. The hourly capacity of a group of gates is defined as the maximum number of aircraft operations that can take place on the gates in an hour under a specified combination of conditions. Gate capacity depends on a number of conditions including, but not limited to, the following:

o Number and types of gates

o Gate mix

o Gate occupancy time

e. <u>Annual Service Volume</u>. Annual Service Volume is a measure of the annual capacity of an airport. Factors considered in determining Annual Service Volume include, but are not limited to:

(1) Level of service; i.e., average delay per aircraft

(2) Hourly demand peak

(3) Daily demand peak

(4) The adverse effect of low capacity periods

f. <u>Annual Delay</u>. Annual Delay is the total delay incurred by aircraft during a year. Factors considered in determining Annual Delay include, but are not limited to:

(1) Total annual demand

(2) Hourly distribution of annual demand

(3) Demand distribution within an hour

(4) Hourly capacity distribution

(5) Annual weather distribution

g. Runway Use Configuration. Runway use configuration is a term used to categorize specific combinations of airfield geometry and operational use.

The geometry includes:

(1) The number of runways in coordinated use. This identifies the unique combination of runways in use during some period of time.

(2) Relative orientation of the runways; i.e., single, parallel, intersecting, open V, etc.

(3) Separation; i.e., centerline separation, distance from threshold to intersection, etc.

The operational use includes:

(1) The direction of operation on the runway.

(2) The kind of operations taking place on each runway; i.e., arrival only, departure only, arrival and departure operations, and touch-and-go operations.

(3) Location of departure roll point; i.e., where on the runway do departures start from?

The definition of runway use configuration is further illustrated by the examples in paragraph 3.7.

h. Aircraft Mix. Aircraft mix is defined in terms of four aircraft classes: A, B, C, and D. In general, the aircraft (e.g., DC10, B727, B99, etc.) included in each aircraft class is at the users discretion. Exceptions to this general rule are noted in paragraphs 2.2.9 and 4.2.4. A recommended definition of aircraft classes is:

Class A - small single-engine aircraft weighing 12,500 lbs. or less;

Class B - small twin-engine aircraft weighing 12,500 lbs. or less and Lear Jets;

Class C - large aircraft weighing more than 12,500 lbs. and up to 300,000 lbs.;

Class D - heavy jet aircraft capable of gross takeoff weights of 300,000 pounds or more.

A list of typical aircraft in each class is presented in Figure 1-1.

The aircraft mix is expressed as the percentage of each aircraft class demand in the total demand; i.e., %A, %B, %C, %D.

i. Percent Arrival. Percent arrival is defined as the percent of all aircraft operations that are arrivals.

Arrival operations can be expected to average 50 percent over an extended period (usually 2 or more hours). However, operations are normally above or below 50 percent for shorter periods (30 minutes to an hour). The impact of high arrival or departure demand peaks on runway capacity can be important. For this reason a range of percent arrivals should be considered. Fifty percent arrivals should not be arbitrarily picked as the best planning number.

For runway use configurations that do not have mixed operations on each runway, the specified value of percent arrival can produce a capacity result that does not use each runway to its full capability. For example, a close parallel runway configuration with arrival operations on one runway and departure operations on the other might have an hourly capacity of 30 arrivals and 50 departures for a total capacity of 80 operations. However, if 50 percent arrivals is specified, the total capacity will be 60. Twenty more departures per hour are possible but are not consistent with the 50 percent arrival requirement. Many runway use configurations can accommodate more departures (and in some cases more arrivals) than are required to satisfy a requirement of 50 percent arrivals. For these configurations the user should consider the capacity that gives the maximum number of arrivals with all possible departures. This is discussed in Chapters 2 and 3 as the 9999 option.

j. Touch-and-GO Operation. A touch-and-go operation refers to an aircraft landing and immediately taking off without making a full stop. It is counted as two aircraft operations.

Significant numbers of touch-and-go operations do not occur at airports used predominately by air carrier aircraft. Therefore, the influence of touch-and-go operations in the planning of such airports may not be important. Touch-and-go operations are important, however, at airports with a high percentage of general aviation aircraft operations.

k. Operating Condition. The operating condition defines the physical, procedural and institutional environment under which arrival and departure operations are conducted. This environment is influenced by the portions of the Air Traffic Control Handbook dictated by ceiling, visibility and other factors; navigational aids present; demand pressure; facility procedures; airline policies; and normal pilot-controller actions. Any number of operating conditions could be defined.

Three operating conditions used in this report are defined below. Each chapter contains further assumptions regarding operating conditions appropriate for that model.

<u>VFR</u>. In the airspace adjacent to an airport with a control zone, VFR (Visual Flight Rule) conditions occur when the ceiling is a least 1000 feet and visibility is at least 3 statute miles. In this environment, aircraft operating under visual flight rules provide their own separation from other aircraft in the traffic pattern. Aircraft coming into the control zone on an IFR flight plan (in VFR weather conditions) are assumed to be cleared for a visual approach when they join the traffic pattern or have the airport in sight. Visual approaches may require that the ceiling be at least 500 feet above the minimum vectoring altitude (which is airport specific). Refer to "Air Traffic Control Handbook" 7110.65 for a more complete discussion of "visual approach."

<u>IFR</u>. IFR (Instrument Flight Rule) conditions occur when the ceiling is less than 1,000 feet and/or visibility is less than 3 statute miles. During IFR conditions, the air traffic control system assumes the responsibility for providing separation between all aircraft. It is assumed that operations in IFR conditions are conducted in a radar environment and that arrivals operate on at least one runway equipped with an instrument landing system (ILS). In IFR conditions operations are assumed to be conducted with "visual separations" once the arrival is below the ceiling or in sight of the airport. Refer to "Air Traffic Control Handbook" 7110.65 for a more complete discussion of "visual separation" in IFR.

<u>PVC</u>. In IFR conditions, the occurrence of certain poor ceiling and visibility conditions may substantially reduce runway capacity. In this report these conditions are called Poor Visibility Conditions or PVC. No visual relief is permitted to the air traffic control separation standards in this environment. However, the controller is assumed to be able to tell (by visual contact or electronics) when an arrival has landed on the runway.

l. <u>Model</u>. The word "model" is used to refer to a set of Fortran IV instructions for calculating capacity or delay. The word model is used in conjunction with 21 unique sets of Fortran IV instructions. These are illustrated on Figure 1-2.

m. <u>Submodel</u>. The word "submodel" is used to refer to the first division of a model. Submodel is only used in connection with runway capacity models. There, it always refers to the strategy for using the runway(s) by arrivals and departures.

n. <u>Branch</u>. The word "branch" is used to refer to the division of a submodel into logical statements for calculating capacity for different operating conditions (VFR, IFR or PVC).

o. Batch Capacity Model. The expression "Batch Capacity Model" is used to refer to all runway capacity models plus the taxiway and gate models. It is called "batch" because inputs to the model are normally made on IBM cards via a card reader.

p. Runway Capacity Model. The expression "runway capacity model" is used to refer to all models that compute hourly runway capacity; i.e., single runway model, two parallel runway model, two intersecting runway model, etc.

q. On-line Model. This expression describes the process of using a teletype timesharing terminal with a computer generated question and answer tutorial program.

1.4 Model Overview

The FAA has developed a series of computer models for the analysis of the airside of an airport. These models can be used to determine the capacity and delay on airports, and to study the fine-grain sensitivity of capacity and delay to variations of airport specific conditions.

Two types of models are available:

a. Analytic Models; i.e., closed form equations.

b. A Critical Event Simulation Model; i.e., a computer representation of time ordered events.

Analytic models were developed to determine the hourly capacity of individual airfield components--the runways, the taxiways and the gates. Capacity submodels were developed for over 100 runway use configurations. One model was developed for determining the hourly capacity of a taxiway crossing a runway. One model was developed for estimating gate capacity. These models calculate capacity as the inverse of the average service time for all aircraft being served. For example, if it takes an average of 45 seconds for aircraft to be "served" on a runway, the capacity of the runway equals one aircraft operation per 45 seconds, or 80 operations per hour. These models treat runways, taxiways, and gates as independent elements.

Analytic models have also been developed for determining Annual Service Volume and Annual Delay. The Annual Service Volume Model computes the product of the weighted average hourly capacity, hourly peaking factor and daily peaking factor. The Annual Delay Model computes delay for each representative hour of the year and produces a weighted average annual delay per operation based on input values of weather and capacity distributions.

The Delay Simulation Model was developed to determine delay per aircraft, travel time, and flow rate information. The model simulates the movement of aircraft from the entry gate of the common approach path to the apron gates, and from the apron gates to takeoff. It treats the airfield components as integrated parts of a system. It is a critical events model that employs Monte Carlo sampling techniques. Because of the modular structure of the model, the total airfield or its individual components can be analyzed by manipulation of the model inputs.

Both the Batch Capacity Model and the Delay Simulation Model can be used to analyze the capacity of an airport. Figure 1-3 provides an overview comparison the model logic for the Batch Capacity Model and the Delay Simulation Model. Generally, the Delay Simulation Model is more versatile, provides more input detail, and is more system oriented than the Batch Capacity Model. However, substantially more time is required to develop inputs for the Delay Simulation Model and much greater computer capacity is required.

On-line models were developed to work in conjunction with the Batch Capacity Model, Annual Delay Model and to compute Annual Service Volume. The On-line Runway Capacity Model is a tutorial program with stored data that accesses the Batch Capacity Model to compute capacity. The model logic (i.e., equations) for the On-line Runway Capacity Model and the Batch Capacity Model are identical. The On-line Annual Delay Model is a special adaptation of the Annual Delay Model. The full input capability of the Annual Delay Model is available through the On-line Annual Delay Model. However, the distributions of capacity, demand and weather are in fixed intervals; i.e., monthly, daily, hourly, VFR, IFR and PVC. As an option, stored data can be called for some parameters. The Annual Service Volume Model is only available in a tutorial on-line model. No built in data is available.

1.5 Model Availability

The models described in this report are available for airport planning. A magnetic tape containing the Batch Capacity Model, the Delay Simulation Model and the On-line Annual Delay Model may be purchased from:

National Technical Information Service
Attn: Order Desk
5285 Port Royal Road
Springfield, Virginia 22161

The program name is: FAA.CAP.AND.DELAY. Magnetic tapes are available in 9 track 800 bpi and 7 track 800 bpi recording modes. The purchase cost of a tape is $60.

In addition, copies of this magnetic tape may be borrowed from:

Chief, Airport Design Branch, ARD-410
DOT/FAA
2100 Second Street, S.W.
Washington, D.C. 20950

(202) 426-3685

on an "as available" basis.

1.6 Configuration Control

Configuration control is being exercised by the FAA over the models contained in this report. This is for the purpose of documenting changes and extending model capabilities. The following are valid programs as of November 1976:

Batch Capacity Model Version 5a
Delay Simulation Model Version 2d
Annual Delay Model Version 1a
On-line Runway Capacity Model Version 2
On-line Annual Service Volume Model Version 1
On-line Annual Delay Model Version 1 (May 1976)

1.7 Computer Requirements

All the computer programs referenced in this report are written in a basic form of FORTRAN IV and should be readily useable on any FORTRAN compatible computer. The following table defines the approximate core requirements for each program.

Model	Core Requirement
Batch Capacity Model Version 5	210k bytes
Delay Simulation Model 3	490k bytes
Annual Delay Version 1	30k (octal) on CDC CYBER 74

1.8 References

a. Procedures for Determination of Airport Capacity, FAA-RD-73-111, Volumes I and II, April 1973, Interim Report, Phase I

This report discusses:

(1) The results of a user survey on what an airport capacity/delay determination report should contain.

(2) The data collection effort conducted in the Fall of 1972.

(3) The model logic concepts for the analytical capacity model.

(4) The model logic concepts for the Delay Simulation Model.

b. Techniques for Determining Airport Capacity and Delay, FAA-RD-74-124, dated June 1976

This report discusses:

(1) An hourly capacity determination procedure via curves.

(2) An approximate hourly delay determination procedure via curves.

(3) The tutorial computer programs for determining runway capacity and annual delay discussed in this report.

(4) Manual calculation of Annual Service Volume.

c. Technical Report on Airport Capacity and Delay Studies, FAA-RD-76-153 dated June 1976

This report discusses:

(1) Capacity and simulation model logic.

(2) The validation of the capacity and simulation model.

(3) Issues related to the production of simplified capacity and delay curves.

d. Supporting Documentation for Technical Report on Airport Capacity and Delay Studies, FAA-RD-76-162, dated June 1976

This report discusses:

(1) Runway Capacity Model inputs for O'Hare validation.

(2) Capacity Model inputs for handbook production.

(3) Description of inputs for the On-line Runway Capacity Model.

(4) Description of inputs for the On-line Annual Delay Model.

e. A Model of the Airfield Surface System, D. Maddison, ITTE, University of California, Berkeley, April 1970

Aircraft Classification	Types of Aircraft
Class A	Small single-engine aircraft weighing 12,500 lbs. or less (e.g., PA18, PA23, C180, C207)
Class B	Small twin-engine aircraft weighing 12,500 lbs. or less and Lear jets (e.g., BE31, BE55, BE80, BE99, C310, C402, LR25)
Class C	Large aircraft weighing more than 12,500 lbs. and up to 300,000 lbs. (e.g., CV34, CV58, CV88, CV99, DC4, DC6, DC7, L188, L49, DC8-10, 20 series, DC9, B737, B727, B720, B707-120, BA11, S210)
Class D	Heavy aircraft weighing more than 300,000 lbs. (e.g., L1011; DC8-30, 40 50, 60 series; DC10; B707-300 series; B747; VC10; A300; Concorde; IL62)

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a. For aircraft type designation, see FAA Order No. 7340.1E with changes.

b. Weights refer to maximum certificated gross take-off weight.

c. Heavy Jet aircraft are capable of 300,000 pounds or more whether or not they are operating at this weight during a particular phase of flight. (Reference: FAA Handbook 7110.8D with changes.)

NOTE: These aircraft classifications generally follow the TERPS categorization. It does not follow the previous categorization used in AC150/5060-1A "Airport Capacity Criteria Used in Preparing the National Airport Plan"; i.e., the "red book."

FIGURE 1-1

AIRCRAFT CLASSIFICATION

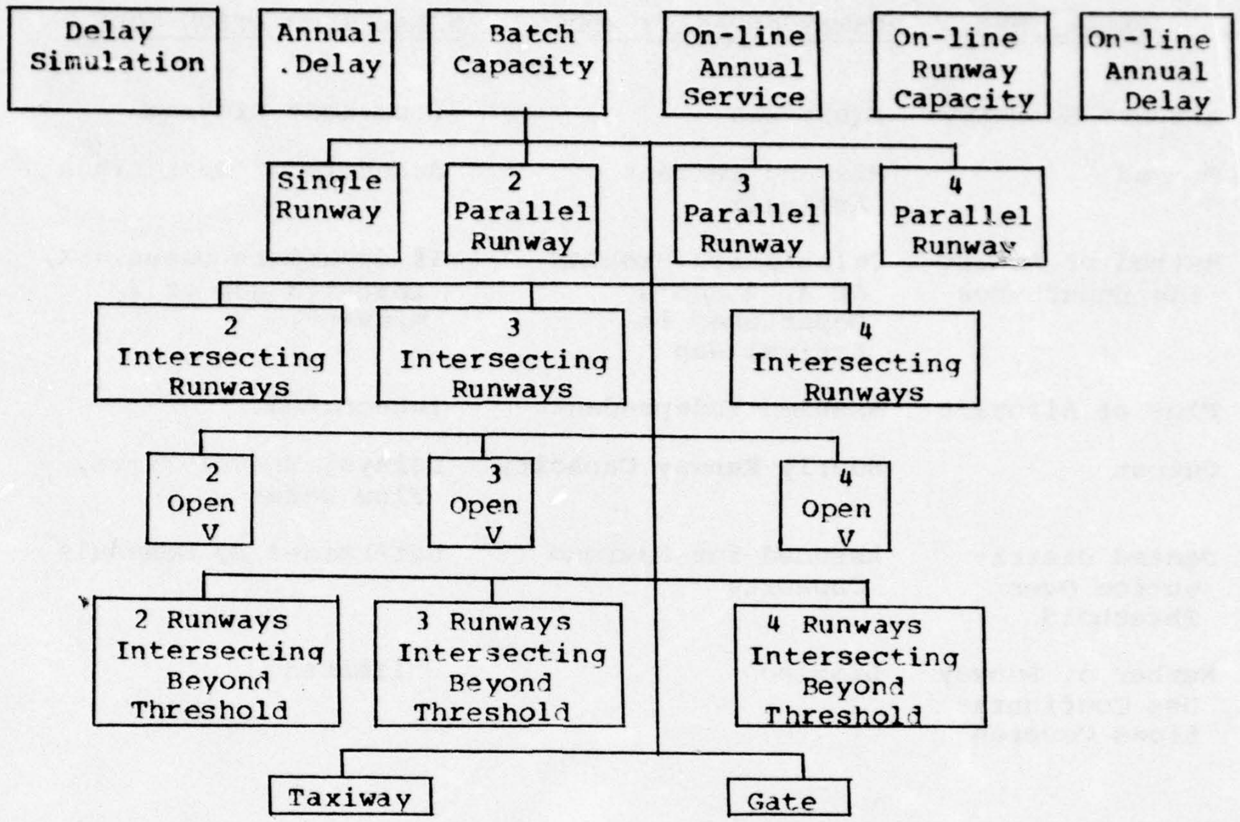


FIGURE 1-2

MODELS

PARAMETERS	RUNWAY CAPACITY MODEL	DELAY SIMULATION MODEL
Airport Geometry	Equations	Link-node Diagram
Demand	Mix and Percent Arrivals	Schedule of Operations
Method of Inserting Departures	Calculation Problem of 1, 2 and 3 Departures in Arrival Gap	If departure Queue = X, insert a gap of Y minutes.
Flow of Aircraft	Assumed Independent	Integrated
Output	Hourly Runway Capacity	Delays, Travel Times, Flow Rates
Demand Distribution Over Threshold	Assumed for Maximum Capacity	Determined by Schedule
Number of Runway Use Configurations Covered	Limited	Unlimited

FIGURE 1-3

COMPARISON OF RUNWAY CAPACITY MODEL WITH DELAY SIMULATION MODEL

CHAPTER 2 - BATCH CAPACITY MODEL VERSION 5 - RUNWAY CAPACITY

2.1 Introduction

Analytic models were developed to determine the capacity of 13 major airfield geometries; i.e.,

GEOMETRY	MODEL No.
Single Runway	1
Two Parallel Runways	2
Two Intersecting Runways	6
Three Parallel Runways	3
Four Parallel Runways	4
Two Open V Runways	5
Three Intersecting Runways	7
Three Open V Runways	10
Four Open V Runways	11
Two Runways Intersecting Beyond Threshold	12
Three Runways Intersecting Beyond Threshold	13
Four Runways Intersecting Beyond Threshold	14
Four Intersecting Runways	15

Typical layouts of these geometries are depicted in Figure 2-1.

Each geometry model contains a series of submodels to account for the strategy with which the active runways are used by arrivals and departures. For example, a parallel runway geometry may be used with arrivals on one runway and departures on the other runway, or arrivals on both runways and departures on one runway, or arrival and departure operations on both runways, or one of several other possible ways. Within each strategy submodel there are logic branches to account for different operating conditions; i.e., VFR, IFR and PVC. Figure 2-2 depicts the hierarchy of model nomenclature used in this chapter.

Each geometry model and associated strategy submodel can be referred to via a two number format; e.g., Model 1-1 refers to model 1 and its associated strategy 1 (i.e., arrivals only); Model 5-3 refers to model 5 and its associated strategy 3 (i.e., mixed operations on Runway 1 and departures on Runway 2). A complete listing of model-strategy combinations in the Runway Capacity Model is contained in Table 2-1. Note: a model-strategy combination defines a runway use configuration.

2.2 Model Logic Summary

The development of the Runway Capacity Model logic equations is contained in references a and c. This paragraph presents a summary of the Runway Capacity Model logic.

2.2.1 Arrival Operations on a Single Runway, Model 1-1

The capacity of an arrival only runway is given by:

$$\text{CAPACITY} = \frac{3600}{\text{average time separation between arrivals}} = \frac{3600}{\text{TAA}}$$

Model 1-1 determines the required time separation for each aircraft class pair (TAAij) by comparing the arrival runway occupancy time of the lead aircraft i and the time separation over threshold for the aircraft pair ij. The larger of these two values is assumed to be the required time separation over threshold for this pair of arrival aircraft classes. The frequency with which each aircraft class pair would occur is assumed to be the product of the mixes of the aircraft classes involved; e.g., the frequency of occurrence of aircraft class pair ij = %i x %j /1000. Therefore, the average time separation between arrival pairs is computed as the product of TAAij for each aircraft class pair and the frequency with which the aircraft class pair is expected to occur.

In determining arrival runway occupancy time and the time between arrivals the Runway Capacity Model considers the variability of aircraft, pilots and controllers as expressed by the standard deviations of arrival runway occupancy time and arrival-arrival separation. In addition, in determining the time between arrivals over the threshold, the Runway Capacity Model considers the approach velocities of the aircraft pair and the length of the common final approach path. If the velocity of the trailing aircraft is equal to or greater than the velocity of the lead aircraft, the specified minimum arrival-arrival separation is assured over the threshold. If the trailing aircraft is operating at a lower velocity than the lead aircraft, the specified minimum arrival-arrival separation is assured at the merge point of the two approach paths.

2.2.2 Departure Operations on a Single Runway, Model 1-2

The capacity of a departure only runway is given by:

$$\text{CAPACITY} = \frac{3600}{\text{average time separation between departures}} = \frac{3600}{\text{TDD}}$$

Model 1-2 determines the required time separation for each aircraft class pair (TDDkl) by comparing the departure runway occupancy time of the lead aircraft k and the time separation between departures (from threshold) for the aircraft pair kl. The larger of these two values is assumed to be the required time separation at threshold for this pair of departure aircraft classes. The average time separation between departures is computed as the product of TDDkl for each aircraft class pair and the frequency with which the aircraft class pair is expected to occur.

2.2.3 Mixed Operations On a Single Runway, Model 1-3

The capacity (without regard to percent arrival) of a single runway used by arrivals and departures is given by:

CAPACITY = (Arrival only runway capacity) + (Number of departures that can be inserted between arrivals)

To insert departures between arrival pairs Model 1-3 imposes the following requirements:

a. Departures cannot roll if an arrival is on the runway.

b. Departures cannot roll if:

(1) An arrival is within some specified distance of the runway threshold, or

(2) The departure cannot clear the runway before the arrival comes over the threshold.

c. Departure-departure separations must be met to insert multiple departures between an arrival pair.

Employing these conditions, Model 1-3 computes the probability of inserting 1, 2 and 3 departures between each arrival pair. The interleaved departure capacity is then determined from these probabilities and the aircraft mix.

One of the specified conditions in determining the mixed operation capacity of a single runway (or any runway use configuration) is the percent arrival. The equation outlined above does not consider the percent arrival. Additional logic is employed by the model to compel the capacity result to reflect the desired percent arrival. This logic is discussed in paragraph 2.2.7.

2.2.4 Simultaneous Arrival Operations on Close Spaced Parallel Runways in VFR, Model 2-19

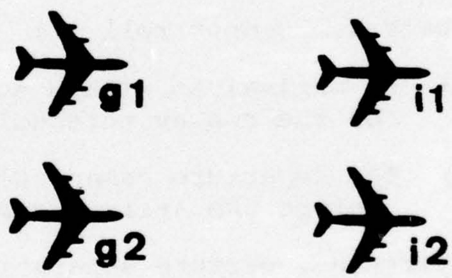
In VFR operating conditions simultaneous arrival operations can be made to close spaced parallel runways; i.e., runways with centerline separations from 700 to 2499 feet, if neither of the aircraft is a heavy jet. When a heavy jet is present on the final approach path, the runways become dependent and the trailing aircraft on both runways are required to observe the single runway wake turbulence separations (e.g., 4 n.mi. for heavy-heavy and large-small, 5 n.mi. for heavy-large and 6 n.mi. for heavy-small aircraft pairs).

To compute capacity (without regard to percent arrival), Model 2-19 considers two conditions:

a) The percent of the time when there is no wake turbulence interaction between the runways.

b) The percent of the time when there is wake turbulence interaction between the runways.

The capacity for condition a) is the sum of the single runway capacities. To compute the capacity of condition b), Model 2-19 considers the following quadruplet of airplanes:



The model first determines the largest specified separation between the lead i1, i2 aircraft and the trailing j1, j2 aircraft. For example, if i1 = C class aircraft, i2 = D class aircraft, j1 = A class aircraft and j2 = C class aircraft, the separation selected for this quadruplet of airplanes would be the specified separation for a D class aircraft followed by an A class aircraft; i.e., it would be assumed that the C-A (i1 j1) and D-C (i2 j2) aircraft would be separated by the input D-A (i2 j1) value of arrival-arrival separation. The model determines this maximum separation value for all possible quadruplets of aircraft classes. The effect of this procedure is to increase the occurrence of large separations. Capacity for condition b) is then the product of the arrival-arrival separation values (or for some aircraft pairs, the arrival runway occupancy time of the lead aircraft) and the frequency of occurrence for each quadruplet of aircraft classes.

The capacity for this runway use configuration is the sum of the capacity for each condition multiplied by its probability of occurrence. The probability of no wake turbulence interaction is equal to (100 - %D)/100 squared. The probability of wake turbulence interaction is given by 1 - (100 - %D)/100 squared.

NOTE: For this runway use configuration, it is possible to specify a buffer time separation between the lead aircraft pair as illustrated below:

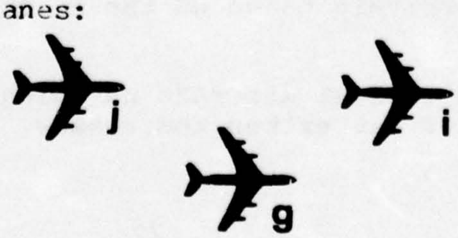
This buffer between simultaneous arrivals is normally used to keep faster wake turbulence producing aircraft from getting ahead of slower aircraft on a parallel approach by the time the aircraft pair reaches the runway thresholds.

To compute the capacity of this geometry with mixed operations on each runway, Model 2-24 determines the number of departures that can be interleaved under conditions a) and b). The capacity for this runway use configuration (without regard to percent arrival) is determined as the sum of the total capacity for each condition and its frequence of occurrence. Note that it is easier to insert departures under condition b) because of the increased occurrence of larger arrival-arrival separations.

2.2.5 Arrival Operations on Intermediate Spaced Parallel Runways in IFR, Model 2-7

As used in this report, intermediate parallel runways are those with centerline separation between 2500 and 4299 feet. In IFR operating conditions, simultaneous arrival approaches cannot be made on these runways. However, since the runway centerline separation is equal to or greater than 2500', no increased arrival separation is required for cross track wake turbulence.

To compute capacity, Model 2-7 considers the following triplet of airplanes:



The arrival-arrival separation for the ij aircraft class pair is the greater of the input arrival separation for the ij class pair or the ig + gj arrival separation where ig and gj are arrival separations without regard to wake turbulence. To determine arrival separations without regard to wake turbulence, the following transformation of input arrival-arrival separations is made:

AIRCRAFT PAIR	EQUIVALENT AIRCRAFT PAIR WITHOUT WAKE TURBULENCE SEPARATION
CA	BB
CB	CC
DA	BA
DB	BB
DC	CC
DD	CD

The capacity of each runway is determined from the single runway arrival only model using the increased ij arrival-arrival separations as determined above and the frequency of occurrence of each triplet of aircraft classes. The capacity for this runway use configuration is then the sum of the capacity of each runway.

To compute the capacity for mixed operations on intermediate parallel runways in IFR, Model 2-12 determines the number of departures that can be interleaved on a single runway with the increased ij arrival-arrival separations as determined above. The mixed operation capacity (without regard to percent arrival) is:

CAPACITY = 2 x (Arrival only runway capacity
using increased arrival-arrival separations)
+ 2 x (Interleaved departure capacity)

2.2.6 Two Intersecting Runways with Arrivals on One Runway and Departures on the Other, Model 6-2

The capacity for this runway use configuration is given by:

CAPACITY = (Single runway arrival only capacity) +
(interleaved departure capacity)

The single runway arrival only capacity is calculated as in paragraph 2.2.1.

Model 6-2 calculates the probability of inserting a departure between two arrivals based on the following conditions being met:

a. The arrival aircraft has cleared the runway intersection or has exited the runway.

b. That at the time the departure begins to roll, the arrival is not within a specified distance of the arrival threshold.

c. That the departure will clear the runway intersection before the arrival comes over the threshold.

If departure and arrival flight paths are projected to cross, additional wake turbulence separation (currently 2 minutes) through the intersection is required. To analyze this special case, the Delay Simulation Model discussed in Chapter 4 is recommended. These conditions could possibly occur when the distance from the arrival threshold to intersection is less than 2000 feet and the distance from departure threshold to intersection is more than 5000 feet.

2.2.7 Percent Arrival Technique

The equations for computing capacity contained in the previous subparagraphs did not consider the desired percent arrival. These equations were based on arrivals having preemptive priority. This condition is referred to as the "9999" percent arrival case. To arrive at the desired percent arrival, the following methodology is used:

a. If the runway use configuration under consideration allows more departures than necessary to satisfy the specified percent arrival, departures are eliminated until the required percent arrival is satisfied.

b. If the runway use configuration under consideration with preemptive arrival priority allows less departures than necessary to satisfy the specified percent arrival, the model calculates the capacity of a revised runway use configuration. The revised runway use configuration is obtained by eliminating all arrival stream(s) that could influence the departure stream(s). Figure A-1 contains the revised runway use configurations used by the model.

The "9999" capacity of the input runway use configuration and revised runway use configuration are then each operated part of the time in proportions that satisfy the specified percent arrival.

c. If the percent arrival of the revised runway use configuration is greater than that needed to satisfy the specified percent arrival, all arrival stream(s) are eliminated. This results in a departure only runway use configuration. The input runway use configuration and the departure only runway use configuration are then each operated part of the time in proportions that satisfy the specified percent arrival.

If, for example, the capacity (without regard to percent arrivals) for a runway use configuration was 35 arrivals and 60 departures, but the user had specified 50% arrival, the model would eliminate the departures in excess of the arrival capacity and list the capacity of the runway use configuration as 35 arrivals and 35 departures for a total of 70 operations/hour. Twenty-five more departures/hour are possible but are not required for the specified percent arrival.

If, for example, the hourly capacity (without regard to percent arrivals) of a single runway with mixed operations was 35 arrivals and 15 departures but the user had specified 50% arrival, an option strategy would be required. The option strategy would be a departure only runway usage for enough time to process 20 (i.e., 35 - 15) departures. If the departure only capacity was 50 operations/hour, this would require 24 minutes (i.e., 60 x 20/50). Now 35 arrivals and 35 departures could be processed in 60 + 24 = 84 minutes. The hourly capacity at 50% arrival would be 50 operations per hour (i.e., 70 x 60/84).

The implication of the percent arrival technique is that the individual runways of a runway use configuration will be used in a fashion that will produce the maximum capacity for the desired percent arrival. For example, if a runway use configuration consisted of parallel runways spaced 1000 feet on centerline with mixed operations on one runway and departures only on the second runway, the model would assume that the bulk of the departures would operate on the second runway. If for some reason the bulk of the departures were constrained to operation on the mixed operations runway, the model would overstate the capacity of the runway use configuration. For example, if a runway use configuration consisted of four parallel runways where two runways were used for mixed operations, one runway was used for arrivals only and one runway was used for departures only, the capacities might be:

		Capacity	
Runway	Operation	Arrival	Departure
1	Mixed	35	25
2	Mixed	35	20
3	Arrival	35	0
4	Departure	0	60
		105	105

The capacity for all four runways at 50% arrivals is 210. However, if the constraint was imposed to have half the demand on runways 1 and 2 and half on runways 3 and 4, the capacity would be substantially less; i.e., 116 + 70 = 186.

When constraints exist on the apportionment of demand per runway within a runway use configuration, it is advisable to

calculate the capacity of each runway or dependent runway pair separately and apply the percent arrival technique manually. This procedure is described in Appendix A.

The percent arrival technique normally gives preemptive priority to arrival operations; i.e., arrivals have first priority for use of the runway and arrival operations are assumed to be conducted at the minimum allowable arrival-arrival separation. Departures are inserted between arrivals on a space available basis. However, for Models 1-3, 2-24 and 6-2, an optional methodology is available to give equal priority to arrival and departure operations. This optional technique will normally produce a higher capacity than the preemptive priority logic because gaps are provided between arrivals to insert departures. The optional technique can only be used for 50% arrivals.

2.2.8 Combinations of Models

The models for the remaining runway use configurations are combinations of the prime equations discussed above. Table 2-1 defines these models. For example, Model 2-16 in VFR is the sum of the capacity for the Single Runway Model with mixed operations and the Single Runway Model with arrivals only. The output capacity is adjusted for the desired percent arrivals. Model 13-2 is made up of the Two Parallel Runway Model with mixed operations for close spaced runways and the Single Runway Model for departures only and the resultant capacity is adjusted for the desired percent arrivals.

2.2.9 Aircraft Mix

In general, the definition of aircraft classes used in the Runway Capacity Model is at the users discretion. However, the logic of the following runway models will treat D type aircraft as wake turbulence producing aircraft and apply special wake turbulence air traffic control separation criteria.

VFR

2-19, 2-21, 2-22, 2-23, 2-24
3-1, 3-2, 3-3, 3-4, 3-7 thru 3-12, 3-18 thru 3-22, 3-28
4-5 thru 4-22, 4-24
7-5
10-1 thru 10-5
11-1 thru 11-4
13-1 thru 13-4
14-1 thru 14-4

IFR

2-7, 2-10, 2-12, 2-13, 2-15, 2-18
3-1, 3-2, 3-4, 3-5, 3-7, 3-9, 3-13, 3-17 thru 3-21,
3-25, 3-28
4-9
5-1
10-1, 10-2, 10-5
11-2
13-2, 13-2
14-2

2.2.10 Runway Specific Mix

The logic for the following models in IFR operating conditions does not consider the mix on each runway:

2-15, 2-19, 2-21, 3-1, 3-28, 3-29, 4-21, 4-22, 4-24, 5-1, 7-3, 7-4, 7-5, 7-6, 10-1, 10-2, 10-5, 11-2, 13-1, 13-2, 14-1, 14-2, 14-3, 14-4, 15-1 and 15-2.

The logic for the following models in VFR operating conditions do not consider the mix on each runway:

7-3, 7-4, 7-5, 7-6, 14-3, 14-4, 15-1, 15-2

For all the above models, the same mix should be applied to each runway. If different mixes are entered for each runway, these models will average the mixes and use this average mix in the computation of capacity. All other runway capacity models will calculate capacity based on the mix specified for each runway. However, if the mix on each runway is not identical, care should be taken to see that the percent arrival technique does not distort capacity. For example, for two parallel runways spaced 5000 feet on centerline in VFR with commerical arrivals and departures using one runway and general aviation using the other runway, the following capacity analysis might result:

	Arrival Capacity	Departure Capacity
Runway 1	35	15
Runway 2	40	60
	75	75

The percent arrival technique applied to both runways would result in a capacity of 150, where as, if the 50% arrival requirement was applied to each runway, the capacity would be 132; i.e.,

	Arrival Capacity	Departure Capacity	Total
Runway 1	26	26	52
Runway 2	40	40	80
			132

assuming a commercial departure only capacity of 60 operations per hour.

2.2.11 Minimum Arrival Separation

The input parameter DLTAIJ is defined as the "minimum" separation between a pair of arrivals over the length of their common approach path. The Runway Capacity Model converts the minimum arrival separation into an average arrival-arrival separation over threshold by the following formula:

Average Separation Over Threshold = (Minimum Separation) + (Control System Buffer) + (Velocity Differential)

or

$$AASR(ij) = 3600 \times DLTAIJ(ij)/V(j) + SIGAA \times FPV + MAX(0, GAMMA(J) \times (IV(j) - IV(i))$$

where

AASR(ij)	=	Arrival-arrival separation requirement in seconds
DLTAIJ(ij)	=	Minimum arrival-arrival separation between two arriving aircraft in nautical miles
V(j)	=	Velocity of the trail aircraft in knots
GAMMA(j)	=	Length of the common approach path for the trail aircraft in nautical miles
V(I)	=	Velocity of the lead aircraft in knots
SIGAA	=	Arrival-arrival separation standard deviation in seconds
FPV	=	The number of standard deviations required to insure that the minimum separations are not violated more than a given percent.
IV(j)	=	1/V(j)
IV(i)	=	1/V(i)

The average arrival-arrival separation over threshold (AASR(ij)) is used by the Runway Capacity Model in the computation of capacity. The minimum arrival-arrival separation DLTAIJ is one factor in determining the average arrival-arrival separation over threshold.

There are several ways to look at the meaning of DLTAIJ and AASR.

a. DLTAIJ can be regarded as the air traffic control separations specified in 7110.65 "Air Traffic Control Handbook." This would be based on the fact that the air traffic control separations are called minimum separations. However, observed separations in saturation conditions do not

lend much support for this position for VFR and IFR operating conditions.

b. AASR can be regarded as the air traffic control separations specified in 7110.65 "Air Traffic Control Handbook." Observed data for commercial aircraft tends to support this position. General aviation aircraft tend to have smaller separations. The values of DLTAIJ can then be calculated from the above equation relating AASR and DLTAIJ.

c. AASR can be regarded as the actual observed separation over the threshold. The input values of DLTAIJ can then be calculated from the above equation relating AASR and DLTAIJ. If data is available, this is the preferred approach.

In analyzing observed time separations over threshold by aircraft pair the user should insure that only values for saturated conditions are considered. Saturation conditions could be inferred if departure queues or arrival holding patterns exist, or they can be inferred by determining the "leading edge" of the arrival-arrival distribution collected during the busy hours. The leading edge is where the first significant amount of observed separations accumulate. Often this occurs around the 35 percentile value.

Methods for converting AASR(ij) values into DLTAIJ(ij) values or DLTAIJ(ij) values into AASR(ij) values are described in Appendix B.

2.2.12 Operating Conditions

The Runway Capacity Model accepts input values for visibility and ceiling. These values determine whether the VFR or an IFR/PVC branch within a submodel will be used to calculate capacity. VFR branches are used if visiblity and ceiling are equal to or greater than 1000 feet and 3 n.mi., otherwise IFR/PVC branches are used. It is not enough, in general, just to specify the visibility and ceiling. All input data (DLTAIJ, TD, SIGAA, GAMMA, etc.) must reflect the desired operating condition; e.g., visual or non-visual approach in VFR, visual or non-visual separation in IFR, Terminal Area Control (TCA) procedures, noise abatement procedures, the impact of limited airfield visibility from the control tower, etc.

Special PVC logic branches exist within a limited number of submodels. When a special PVC logic branch does not exist, the IFR logic branch is used for all ceiling and visibility conditions less than 1000 feet and 3 nautical miles. Special PVC branches exist within the following models:

2-14	2-20	3-1
2-16	2-22	3-18
2-17	2-23	10-5
2-18	2-24	

If PVC branches exist within a submodel, visibility and ceiling inputs do not determine whether the IFR or PVC branch will be used. This is determined by the value of DLTADA (departure-arrival separation). If the value of DLTADA is greater than zero for the above models, a PVC branch will be used. To execute an IFR branch for the above models, the input value of DLTADA must be zero. If a special PVC branch does not exist, the parameter DLTADA can take on any value desired.

2.3 Input Format

The following general instructions apply to preparing inputs to the Runway Capacity Model:

a. Data entry requires two card types; i.e.,

Header Card; e.g., Runway 1 1

Data Card(s); e.g., 0.250.250.250.25

b. There is no fixed sequence for groups of header/data cards.

c. Unless otherwise noted on the form by decimal points, right justify all numbers.

d. To execute a run, place a 1 in card column 12 of the header card for the last data group.

e. Multiple runs can be made with one stack of cards. Place replacement header/data cards after the execute card for the first complete run. This is illustrated in Examples 1 and 2.

f. The space between card columns 13 and 80 on all header cards can be used to print explanatory text (e.g., DENVER TEST 1).

g. Any six letter title can be used in card columns 1-6 of the header card.

h. On the header card:

cc	1-6	Title
cc	8	Runway number when appropriate
cc	9-10	Data type number
cc	12	Execute command (i.e., 1)
cc	13-80	Text

i. The coding form is constructed for up to 2 runways. For 3 or 4 runway systems, add additional RUNWAY, ARBAR, and EXIPT cards.

j. Runways that accommodate arrival operations require arrival runway occupancy time (ARBAR2) and exit utilization (EXIPT) data. Other runways do not require this data.

k. The following data types are required for all runway models:

NEWRUN - 0	APPSPD - 5
RUNWAY - 1	DRBAR - 6
ARBAR2 - 2	TD - 7
EXIPT - 3	GAMA - 8
DLTAIJ - 4	OTHERS - 20

l. The following matrix defines data types required for some runway models:

MODEL NAME	NUMBER	DATA TYPE OPEN V	ADSR	DICBR	BDD	BAA
TWOPA	2				x	x
THREPA	3				x	x
FOURPA	4				x	x
OPENV2	5	x				
TWOIN	6		x	x		
THREIN	7		x	x	x	x
OPENV3	10	x			x	x
OPENV4	11	x			x	x
TWOINB	12	x				
THRINB	13	x			x	x
FOURINB	14	x	x	x	x	x
FOURIN	15		x	x	x	x

m. An input value of zero for DLTAIJ means that the arrival-arrival separation is to be determined by the time necessary for the lead arrival to clear the runway plus a control system buffer plus velocity differential.

A sample coding form with header labels and decimal points is shown in Figure 2-3. It is recommended that a similar form be used to prepare card inputs. The definition of terms used in the coding form are given below:

DEFINITION OF TERMS USED ON CODING FORM

TERM	DEFINITION
NEWRUN	- A header label used with model/strategy data

MODEL - A number used to define the model type; e.g., single runway is 1, parallel runway 2, etc. Model numbers are given in Table 2-1.

STRATEGY - A number used to define which runways have arrival, departure or arrival and departure operations. Strategy numbers are given in Table 2-1.

F - If F = 1, the model will compute capacity with equal arrival and departure priorities. If F = 0, the model will compute capacity for preemptive arrival priority.

RUNWAY - A header label used with the mix of aircraft.

APPSPD - A header label used with average ground speed over the common final approach path in knots.

DRBAR - A header label used with the departure runway occupancy time in seconds.

GAMA - A header label used with the length of common final approach path in n.mi.

TGRBAR - A header label used with touch-and-go runway occupancy time in seconds, only needed if the percent of touch-and-go operations (POTG) is greater than zero.

MODIAS - A header label used when calculating the sensitivity of capacity to arrival-arrival separation. The header/data cards can be ommitted if the information is not required.

ISTR - If ISTR = 0, the model calculates capacity for preemptive arrival priority.

If ISTR = 1, the model will calculate capacity with a value of DLTAIJ selected by the model to allow a departure to be inserted between each arrival pair.

If ISTR = 2, the model will calculate capacity at the inputted values of DLTAIJ plus the capacity at seven preselected increments of arrival-arrival separation up to the value of MAXD.

If ISTR = 3, the model will calculate capacity for the inputted values of DLTAIJ plus the capacity at a series of incrementally increased values of DLTAIJ up to the value of MAXD.

If ISTR = 4, the model will calculate capacity for the inputted values of DLTAIJ plus all possible combinations of DLTAIJ values up to MAXD.

If ISTR = 5, the model will calculate capacity for ISTRATEGY = 1 and 2.

If ISTR = 6, the model will calculate capacity for ISTRATEGY = 1 and 3.

PRINT - If PRINT = 0, all capacity values resulting from the runs will be printed.

If PRINT = 1, the maximum capacity value resulting from the runs will be printed.

INC - The increment by which you want to vary DLTAIJ in ISTR 3, 4 and 6.

MAXD - The largest value of DLTAIJ to be considered in the capacity computations.

DLTAIJ - A header label used with the minimum separation between two arrival aircraft in n.mi.

TD - A header label used with the required separation between a pair of departures in seconds.

BAA - A header label used with the buffer between a pair simultaneous arrivals on parallel runways in seconds.

OTHERS - A header label used with miscellaneous data.

SIGAR - The standard deviation of arrival runway occupancy time in seconds.

SIGAA - The standard deviation of arrival-arrival separation in seconds.

PV - The statistical probability of violation of the minimum air traffic control rules.

SIGDR - The standard deviation of departure runway occupancy time in seconds.

SIGAC - The standard deviation of cleared to roll time.

DLTADA - The departure-arrival separation in nautical miles for all runway use configurations except two intersecting runways.

VIS - Visibility at the arrival threshold in nautical miles.

CEILING - Ceiling in feet.

G. SLOPE - Glide slope angle in degrees. (Must be equal to or greater than 1 degree.)

POTG - Percent of touch-and-go operations. Only appliable to single and two parallel runways in VFR.

SIGTGS - The standard deviation of touch-and-go time in seconds.

OPENV - The header label used with open V data.

ANGLE - The angle between nonparallel runways in degrees.

OPENVX - The distance between:

The centerline of Runway 1 and the threshold of Runway 2 for models 5 and 12.

The centerline of Runway 1 and the threshold of Runway 3 for models 10 and 13.

The centerline of Runway 1 and the threshold of Runway 4 for models 11 and 14.

STWOIN - The header label used with data for two intersecting runways when MODIAS is used.

X - The distance in feet from arrival threshold to intersection.

Y - The distance in feet from departure roll to intersection.

SIGAI - The standard deviation of ADSR values.

SIGDI - The standard deviation of DICBR values.

ADSR - The header label used with the arrival-departure separation on two intersecting runways; i.e., arrival intersection clearance time in seconds.

DICBR - The header label used with the departure-arrival separation in nautical miles for two intersecting runways.

ARBAR2 - The header label used with the arrival runway occupancy time in seconds. ARBAR2 data is only needed for runways serving arrivals.

EXIPT - The header label used with the probability of using arrival exit. EXIPT data is only needed for runways serving arrivals.

BDD - The header label used with the buffer between simultaneous departures on close parallel runways in seconds.

BAA - The header label used with the buffer between simultaneous arrivals on close parallel runways in seconds.

A - Class A aircraft.
B - " B "
C - " C "
D - " D "
AA - Class A aircraft followed by a class A aircraft.
AB - " A " " " B "
AC - " A " " " C "
AD - " A " " " D "
BA - " B " " " A "
BB - " B " " " B "
BC - " B " " " C "
BD - " B " " " D "
CA - " C " " " A "
CB - " C " " " B "
CC - " C " " " C "
CD - " C " " " D "
DA - " D " " " A "
DB - " D " " " B "
DC - " D " " " C "
DD - " D " " " D "
EX1 thru
EX11 - Exit 1 through Exit 11 for the designated runway in cc 8 of EXIPT.

2.4 Output

The basic output of the Runway Capacity Model is the total capacity per hour for a specified percent arrival. This capacity is without regard to delay considerations.

The model output provides information on the manner in which the desired percent arrivals are obtained. For example, if the output states: "TO OBTAIN 50% ARRIVAL, AVAILABLE DEPARTURE CAPACITY IS REDUCED BY 30 OPERATIONS/HOUR.", the runway use configuration has more departure capcity than is required by the specified percent arrivals. The number of reduced departures can be added to the departure capacity at the specified percent arrival to determine the maximum number of departures possible. If, however, the output states: "TO OBTAIN 50% ARRIVAL, GAPS IN THE ARRIVAL STREAM MUST EXIST DURING 30 PERCENT OF THE HOUR.", it is very difficult to get off the required numbered departures in this runway use configuration. Arrivals will have to be spaced out farther or gaps created.

The model output provides a listing of inputs with each run. This provides a convenient method of debugging inputs and a permanent record of inputs. For multiple runs with a single deck, the model will list the complete set of inputs for the

first capacity followed by the capacity, then the first set of input value replacements followed by the capacity, then more replacement values followed by their capacity, etc., until all cards have been read.

NOTE: To compute hourly delay, Figure 2-68 in reference b can be used. The procedure for computing hourly delay is explained in paragraphs 27 and 28 of this report. However, the delay factors ADF and DDF should be calculated using Appendix D.

2.5 Data Input Modes

It is possible to use the Runway Capacity Model in two input modes; i.e.,

- o Remote Job Entry (RJE) via cards
- o From a teletype terminal using stored files

Remote job entry requires that all data be punched on IBM cards and be processed by a card reader. Job cards are required to load the capacity model and to identify the user for billing purposes. Model output is printed on a remote printer.

In the teletype terminal mode the user can construct input files and call for model executions directly from his work area. The input format is exactly the same as with cards. To call for an execution, a series of computer instructions are entered at the teletype terminal. These instructions can themselves be stored in the computer and called for by a Command File or CLIST.

The FAA has established command files on TYMSHARE and McAuto for operation of the Runway Capacity Model from a teletype terminal. To use this command file requires that the input data be placed in a temporary file named BATCH.SUB and that the command EX TER be entered. This will result in a complete execution of the Runway Capacity Model. After execution, the input file BATCH.SUB can be renamed and permanently stored, or edited and reexecuted.

As an option, the On-line Runway Capacity Model discussed in Chapter 3 can be used to quickly construct the bulk of the input data required for a complete batch run. The procedure is:

a) rename the temporary file (OUTPUT.DATA on TYMSHARE or INPUT.DATA on McAuto) created by the On-line Runway Capacity Model as BATCH.SUB;

b) edit this file as appropriate;

c) enter the command EX TER.

2.6 Examples

The following examples illustrate the use of Runway Capacity Model Version 5.

Example 1

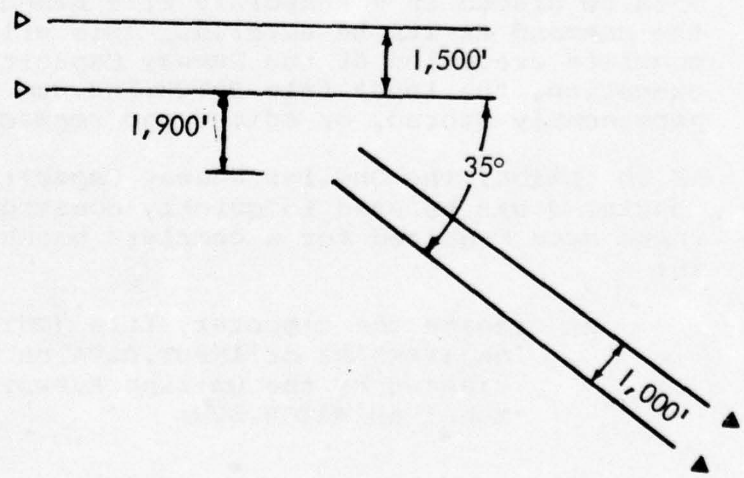
Compute the saturation hourly capacity of a single runway general aviation airport for 30, 50 and 70% arrivals in VFR operating conditions. The aircraft mix consists of 85%A and 15%B aircraft. Touch-and-go operations account for 20% of the airport operations. Assume typical values for all other parameters; i.e., values used to generate Figure 2-3 of reference b.

From Table 2-1, the runway use configuration is identified as Model 1-3. Figure 2-4 shows the coding form for the Runway Capacity Model with input data filled in. From the computer output shown in Figure 2-5, the saturation hourly capacities are: ties are:

PERCENT ARRIVAL	SATURATION CAPACITY
30	127.6 operations/hour
50	113.8 operations/hour
70	102.7 operations/hour

Example 2

Compute the saturation hourly capacity of the runway use configuration shown below for 50% arrivals in IFR operating conditions.



Also, compute the saturation hourly capacity without regard to percent arrival. The aircraft mix consists of 3%A, 7%B, 70%C and 20%D aircraft. There are no touch-and-go operations. Standard exits are located at 1500', 3000', 4000', 5500', 7000', and 10000' from threshold for both runways 1 and 2. Assume typical values for all other parameters.

A table for estimating arrival runway occupancy time (i.e., ARBAR2) is shown in Table 2-2. A table for estimating exit utilization (i.e., EXIPT) is shown in Table 2-3. From these tables, the following results:

EXIT	ARBAR2				EXIPT			
LOCATION	A	B	C	D	A	B	C	D
1500	29	27	29	34	45	-	-	-
3000	44	37	29	34	55	38	-	-
4000	-	46	38	38	-	59	8	-
5500	-	60	51	51	-	2	62	40
7000	-	75	65	65	-	-	30	58
10000	-	75	85	85	-	-	-	2

From Table 2-1, the runway use configuration is identified as Model 14-1. From the computer output shown in Figure 2-6, the saturation hourly capacities are:

a) 50% arrival

Arrivals = 32.7
Departures = 32.7
Total 65.4

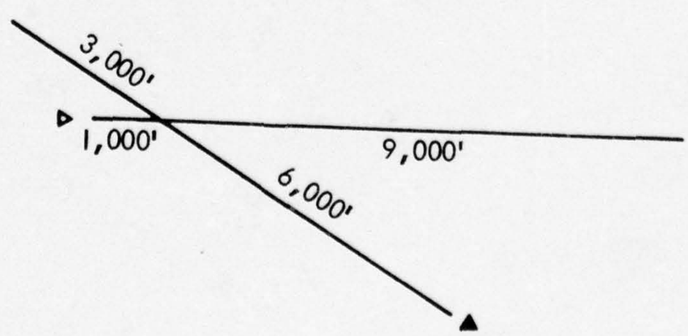
b) Capacity without to percent arrival

Arrivals = 32.7
Departures = 50.9
Total 83.6

NOTE: 18.2 more departures are possible but are not required for 50% arrivals.

Example 3

Compute the saturation hourly capacity of the intersecting runway configuration shown below for 50% arrivals in IFR operating conditions.



The aircraft mix consists of 60%C and 40%D aircraft. There are no touch-and-go operations. Assume that arrival and departure operations have equal priority for use of the runway, all arrivals can operate at a minimum separation (DLTAIJ) of 2 nautical miles, and that all departure-departure separations are 60 seconds. High-speed exits are located at 3000', 4000', 5000', 6000', 7000' and 9000' from the threshold of runway number 1. Assume typical values for all other parameters.

A table for estimating ADSR is shown in Table 2-4. A table for estimating DICBR is shown in Table 2-5. From these tables, the following result:

	A	B	C	D
ADSR (seconds)	5.0	5.0	5.0	5.0
DICBR (n.mi.)	1.0	1.0	1.0	1.0

From Table 2-1, the runway use configuration is identified as Model 6-2. From the computer output shown in Figure 2-7, the saturation hourly capacity is determined to be 95.7 operations per hour.

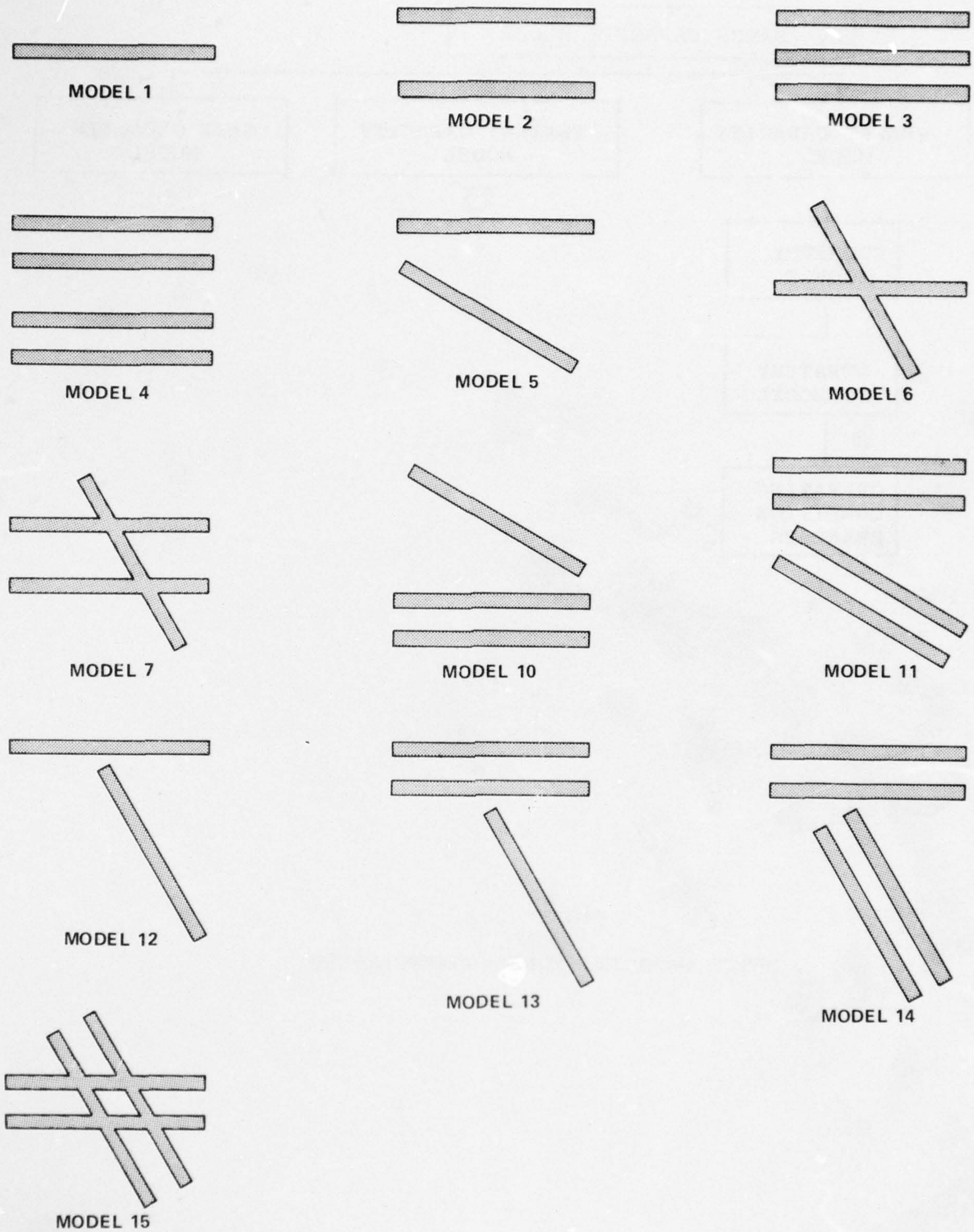


Figure 2 - 1

RUNWAY USE CONFIGURATION GEOMETRICS

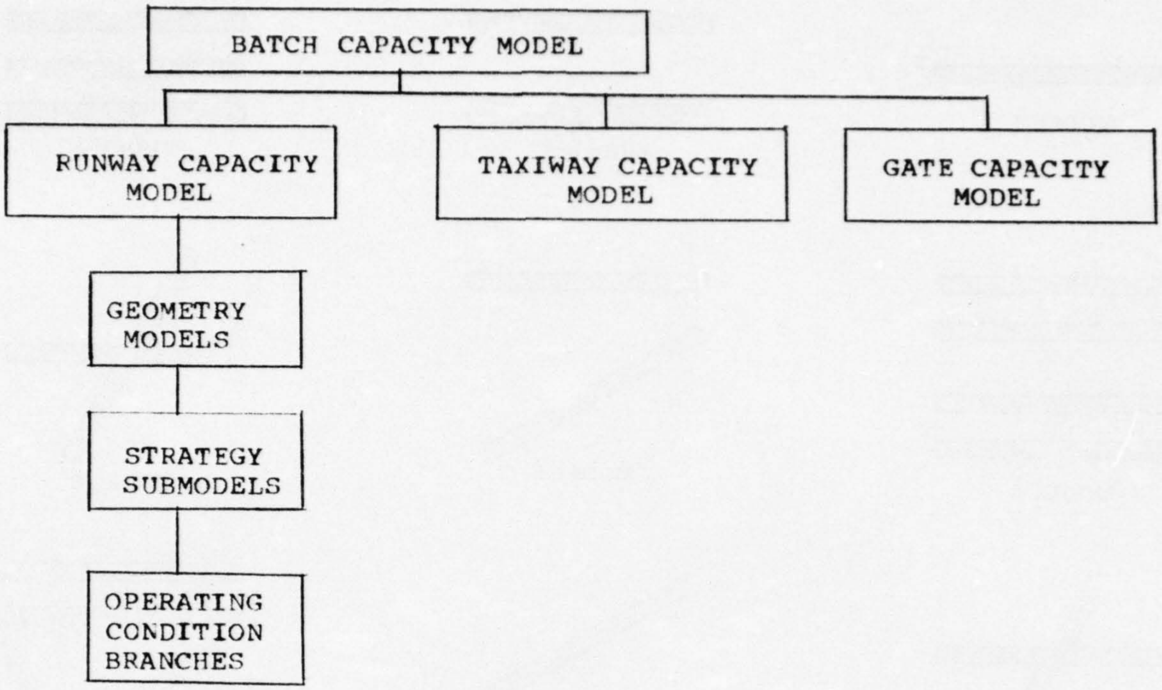


FIGURE 2-2

BATCH CAPACITY MODEL NOMENCLATURE

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CODING FORM FOR BATCH CAPACITY MODEL VERSION 5

FIGURE 2-3

RUNWAY CAPACITY

1–4	5–8	9–12	13–16	17–65
				text
N E W R	U N			
model	strategy	f		
				text
R U N W	A Y 1	1		
a	b	c	d	
.	.	.	.	
				text
R U N W	A Y 2	1		
.	.	.	.	
				text
A P P S	P D	5		
a	b	c	d	
				text
D R B A	R	6		
a	b	c	d	
				text
G A M A		8		
a	b	c	d	
				text
T G B A	R	9		
a	b	c	d	
.	.	.	.	
				text
M O D I	A S	2 3		
istr	print	inc	max d	

CODING FORM FOR BATCH CAPACITY MODEL VERSION 5

FIGURE 2-3

RUNWAY CAPACITY

1–4	5–8	9–12	13–16	17–20	21–24	25–28	29–32	33–36	37–40	41–44	45–48	49–52	53–56	57–60	61–64
B D D		2 2													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
D L T A	I J	4													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
T D		7													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
B A A		2 4													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
O T H E	R S	2 0													
sigar	sigaa	pv	sigdr	sigac	dltada	vis	ceiling	g.slope	potg	sigtgr	pa%				
O P E N	V	1 0													
angle	openvx														
S T W O	I N	1 1													
x	y	sigai	sigdi												
A D S R	1	1 2													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
D I C B	R	1 3													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd

DAC 25-1213C (REV 8-63)

CODING FORM FOR BATCH CAPACITY MODEL VERSION 5

FIGURE 2-3

RUNWAY CAPACITY

ARBAR2 1 2
a
b
c
d

EXIPT 1 3
a
b
c
d

ARBAR2 2 2
a
b
c
d

EXIPT 2 3
a
b
c
d

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CODING FORM FOR BATCH CAPACITY MODEL VERSION 5

CODING FORM FOR EXAMPLE 1
FIGURE 2-4

RUNWAY CAPACITY

1–4	5–8	9–12	13–16	17–20	21–24	25–28	29–32	33–36	37–40	41–44	45–48	49–52	53–56	57–60	61–64
BDD		22													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DLTAIJ		4													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
0.	0.	2.3	2.5	0.	0.	2.3	2.5	2.5	3.1	3.0	3.1	3.4	4.3	4.6	4.1
TD		7													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
25	30	40	50	30	40	45	50	45	45	55	60	120	120	120	90
BAA		24													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
OTHERS		20 1													
sigar	sigaa	pv	sigdr	sigac	dltada	vis	ceiling	g.slope	potg	sigtgr	pa%				
6.	~~8~~.	.04	5		.	5.	3500	3.	.2	7.	50				
OPENV		10													
angle	openvx														
STWOIN		11													
x	y	sigai	sigdi												
ADSR		112													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DICBR		13													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

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CODING FORM FOR BATCH CAPACITY MODEL VERSION 5

CODING FORM FOR EXAMPLE 1
FIGURE 2-4

RUNWAY CAPACITY

```
1234567890
ARBAR2 1 2
a
32.
b
40.
c
51.
d
58.
EXIPT  1 3
a
1.10
b
1.0
c
1.0
d
1.10
ARBAR2 2 2
a
b
c
d
EXIPT  2 3
a
b
c
d
```

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CODING FORM FOR BATCH CAPACITY MODEL VERSION 5

CODING FORM FOR EXAMPLE 1
FIGURE 2-4

RUNWAY CAPACITY

1–4	5–8	9–12	13–16	17–66
NEWR	UN			text
				CARL T BALL, ARD-410
model	strategy	f		
1	3			
RUNW	AY 1	1		text
a	b	c	d	
.85	.15	.	.	GA AIRPORT
~~RUNW~~	~~AY 2~~	1		text
~~.~~	~~.~~	~~.~~	~~.~~	
APPS	PD	5		text
a	b	c	d	
80	100	130	140	
DRBA	R	6		text
				AVERAGE INPUTS
a	b	c	d	
24	29	39	39	
GAMA		8		text
a	b	c	d	
1	1	6	6	
TCBA	R	9		text
a	b	c	d	
23.	22.	27.	27.	
MODI	~~AS~~	23		text
istr	~~print~~	inc	max d	

CODING FORM FOR BATCH CAPACITY MODEL VERSION 5

RUNWAY CAPACITY

CODING FORM FOR EXAMPLE 1

FIGURE 2-4

1-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32	33-36	37-40	41-44	45-48	49-66
OTHE	RS	20 1										
6.0	0.0	.04	5			5.0	3500	3.0	.2	7.0	30	
OTHE	RS	20 1										
6.0	0.0	.04	5			5.0	3500	3.0	.2	7.0	70	

COMPUTER RUN FOR EXAMPLE 1

FIGURE 2-5

```
NEWRUN 0 0 0              CARL T BALL,  ARD-410                           00000010
   1   3   0
RUNWAY 1 1 0                    GA AIRPORT                                00000030
0.850.150.0 0.0
ARBAR2 1 2 0                                                              00000050
32.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
40.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
51.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
58.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
EXITPT 1 3 0                                                              00000100
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
DLTAIJ 0 4 0                                                              00000150
 0.0 0.0 2.3 2.5 0.0 0.0 2.3 2.5 2.5 3.1 3.0 3.1 3.4 4.3 4.6 4.1
APPSPD 0 5 0                                                              00000170
  80 100 130 140
DRBAR  0 6 0                  AVERAGE INPUTS 0                            00000190
  24  29  39  39
TD     0 7 0                                                              00000210
  25  30  40  50  30  40  45  50  45  45  55  60 120 120 120  90
GAMA   0 8 0                                                              00000230
   1   1   6   6
TGRBAR 0 9 0                                                              00000250
23.022.027.027.0
OTHERS 020 1                                                              00000270
 6.0 0.0.040   5   0 0.0 5.03500 3.00.20  7.  30
SINGLE RUNWAY MIXED OPERATIONS WITH T & G

BATCH CAPACITY PROGRAM, VERSION 5

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***


              TOTAL =    127.6  ARRIVAL =    38.3  DEPARTURE =    89.3



OTHERS 020 1                                                              00000350
 6.0 0.0.040   5   0 0.0 5.03500 3.00.20  7.  50
SINGLE RUNWAY MIXED OPERATIONS WITH T & G

BATCH CAPACITY PROGRAM, VERSION 5

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***


              TOTAL =    113.8  ARRIVAL =    56.9  DEPARTURE =    56.9
```

```
OTHERS 020 1                                                          00000370
 6.0 0.0.040    5    0 0.0 5.03500 3.00.20  7.  70
SINGLE RUNWAY MIXED OPERATIONS WITH T & G

BATCH CAPACITY PROGRAM, VERSION 5

                  ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***


                  TOTAL =    102.7  ARRIVAL =    71.9  DEPARTURE =    30.8
```

COMPUTER RUN FOR EXAMPLE 1

FIGURE 2-5 (Cont.)

COMPUTER RUN FOR EXAMPLE 2
FIGURE 2-6

```
NEWRUN 0 0 0                                                                        00000010
  14   1   0
RUNWAY 1 1 0                                                                        00000030
0.030.070.700.20
RUNWAY 2 1 0                                                                        00000050
0.030.070.700.20
RUNWAY 3 1 0                                                                        00000070
0.030.070.700.20
RUNWAY 4 1 0                                                                        00000090
0.030.070.700.20
ARBAR2 1 2 0                                                                        00000110
29.044.055.070.576.076.0 0.0 0.0 0.0 0.0 0.0
27.037.046.060.575.075.0 0.0 0.0 0.0 0.0 0.0
29.029.038.051.565.085.0 0.0 0.0 0.0 0.0 0.0
34.034.038.051.565.085.0 0.0 0.0 0.0 0.0 0.0
ARBAR2 2 2 0                                                                        00000160
29.044.055.070.576.076.0 0.0 0.0 0.0 0.0 0.0
27.037.046.060.575.075.0 0.0 0.0 0.0 0.0 0.0
29.029.038.051.565.085.0 0.0 0.0 0.0 0.0 0.0
34.034.038.051.565.085.0 0.0 0.0 0.0 0.0 0.0
EXITPT 1 3 0                                                                        00000210
0.450.550.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.380.590.020.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.080.620.300.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.400.580.020.0 0.0 0.0 0.0 0.0
EXITPT 2 3 0                                                                        00000260
0.450.550.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.380.590.020.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.080.620.300.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.400.580.020.0 0.0 0.0 0.0 0.0
DLTAIJ 0 4 0                                                                        00000310
 2.3 2.1 2.3 2.5 2.3 2.1 2.3 2.5 3.8 3.6 2.3 2.3 5.8 5.6 4.6 3.5
APPSPD 0 5 0                                                                        00000330
  95 120 130 140
DRBAR  0 6 0                                                                        00000350
  29  34  39  39
TD     0 7 0                                                                        00000370
  50  50  60  60  55  55  60  60  60  60  60  60 120 120 120  90
GAMA   0 8 0                                                                        00000390
   6   6   6   6
TGRBAR 0 9 0                                                                        00000410
23.022.027.027.0
OTHERS 020 0                                                                        00000430
 6.015.0.040   3    0 0.0 2.5 800 3.00.0    7.  50
MODIAS 023 0                                                                        00000450
   0    0 0.0 0.0
BDD    022 0                                                                        00000470
 0.0 0.0 0.025.0 0.0 0.0 0.020.0 0.0 0.0 0.010.025.020.010.0 0.0
BAA    024 1                                                                        00000490
 0.0 0.0 0.025.0 0.0 0.0 0.020.0 0.0 0.0 0.010.025.020.010.0 0.0
FOUR INTER BEYOND, AWAY, ARR ON #1, #2, DEP ON #3, #4

BATCH CAPACITY PROGRAM, VERSION 5
TO OBTAIN  50 PERCENT ARR, AVAILABLE DEPARTURES CAPACITY IS REDUCED BY  18.2
 OPERATIONS PER HOUR


          ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***
```

TOTAL = 65.4 ARRIVAL = 32.7 DEPARTURE = 32.7

OTHERS 020 1 00000510
6.015.0.040 8 0 0.0 2.5 800 3.00.0 7.9999
FOUR INTER BEYOND, AWAY, ARR ON #1, #2, DEP ON #3, #4

BATCH CAPACITY PROGRAM, VERSION 5
ARRIVALS 1ST PRIORITY & DEPARTURES 2ND PRIORITY WITHOUT REGARD TO PERCENTAGE ARRIVALS

*** AIRFIELD HOURLY RUNWAY CAPACITY ***

TOTAL = 83.6 ARRIVAL = 32.7 DEPARTURE = 50.9

FIGURE 2-6 (Cont.)

```
NEWRUN 0 0 0
   6    2    1
RUNWAY 1 1 0
0.0 0.0 0.600.40
RUNWAY 2 1 0
0.0 0.0 0.600.40
ARBAR2 1 2 0
43.043.043.043.043.043.0 0.0 0.0 0.0 0.0 0.0
32.041.049.049.049.049.0 0.0 0.0 0.0 0.0 0.0
35.035.044.054.063.063.0 0.0 0.0 0.0 0.0 0.0
35.035.044.054.063.063.0 0.0 0.0 0.0 0.0 0.0
EXITPT 1 3 0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.400.580.020.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.260.500.220.020.0 0.0 0.0 0.0 0.0 0.0
0.0 0.030.520.400.050.0 0.0 0.0 0.0 0.0 0.0
DLTAIJ 0 4 0
 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0
APPSPD 0 5 0
  95 120 130 140
DRBAR   0 6 0
  29   34   39   39
TD      0 7 0
  60   60   60   60   60   60   60   60   60   60   60   60   60   60   60   60
GAMA    0 3 0
   6    6    6    6
TGRBAR 0 9 0
23.022.027.027.0
ADSR    112 0
 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0
DICBR   013 0
 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
OTHERS 020 1
 6.0 8.0.010    8    0 0.0 2.5 800 3.00.0    7.   50

BATCH CAPACITY PROGRAM, VERSION 5


           ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***


           TOTAL =     90.1  ARRIVAL =     45.1  DEPARTURE =     45.1
```

COMPUTER RUN FOR EXAMPLE 3
FIGURE 2-7

Model No.	Separation: Operation Per Runway	Model Logic Summary VFR	IFR
1	Single Runway		
1-1	A	Prime Equation	Prime Equation
1-2	D	Prime Equation	Prime Equation
1-3	B	Prime Equation	Prime Equation
2	Two Parallel Runways		
2-1	F:A,A	(1-1) + (1-1)	(1-1) + (1-1)
2-2	F:A,D	(1-1) + (1-2)	(1-1) + (1-2)
2-3	F:D,D	(1-2) + (1-2)	(1-2) + (1-2)
2-4	F:B,A	(1-3) + (1-1)	(1-3) + (1-1)
2-5	F:B,D	(1-3) + (1-2)	(1-3) + (1-2)
2-6	F:B,B	(1-3) + (1-3)	(1-3) + (1-3)
2-7	M:A,A	(1-1) + (1-1)	Prime Equation
2-8	M:A,D	(1-1) + (1-2)	(1-1) + (1-2)
2-9	M:D,D	(1-2) + (1-2)	(1-2) + (1-2)
2-10	M:B,A	(1-3) + (1-1)	Prime Equation
2-11	M:B,D	(1-3) + (1-2)	(1-3) + (1-2)
2-12	M:B,B	(1-3) + (1-3)	Prime Equation
2-13	N:A,A	(1-1) + (1-1)	Prime Equation (same as 2-7)
2-14	N:A,D	(1-1) + (1-2)	(1-1) + (1-2)
2-15	N:D,D	(1-2) + (1-2)	Prime Equation
2-16	N:B,A	(1-3) + (1-1)	(1-3) + (1-1)
2-17	N:B,D	(1-3) + (1-2)	(1-1) + (1-2)
2-18	N:B,B	(1-3) + (1-3)	Prime Equation
2-19	C:A,A	Prime Equation	(1-1)
2-20	C:A,D	(1-1) + (1-2)	(1-1) + (1-2)
2-21	C:D,D	Prime Equation	(1-2)
2-22	C:B,A	Prime Equation	(1-1) + (1-2)
2-23	C:B,D	Prime Equation	(1-1) + (1-2)
2-24	C:B,B	Prime Equation	(1-1) + (1-2)

BEFORE COLON

C = 700 to 2499 ft.
N = 2500 to 3499 ft.
M = 3500 to 4299 ft.
F = 4300 ft. or more

AFTER COLON
(operations by runway numbers)

A = Arrival only
D = Departure only
B = Both arrivals and departures

TABLE 2-1

RUNWAY CAPACITY MODELS

Model No.	Separation: Operation Per Runway	Model Logic Summary VFR	IFR
3	Three Parallel:	Runway 1-2 are close parallels.	
3-1	C:B,B,B	Prime Equation	(2-18)
3-2	N:B,B,B	(2-24) + (1-3)	(1-2) + (2-10)
3-3	F:B,B,B	(2-24) + (1-3)	(1-1) + (1-2) + (1-3)
3-4	C:A,D,B	(1-1) + (2-23)	(1-2) + (2-7)
3-5	N:A,D,B	(1-1) + (1-2) + (1-3)	(1-2) + (2-7)
3-6	F:A,D,B	(1-1) + (1-2) + (1-3)	(1-1) + (1-2) + (1-3)
3-7	N:B,B,A	(2-24) + (1-1)	(1-2) + (2-7)
3-8	F:B,B,A	(2-24) + (1-1)	(1-1) + (1-2) + (1-1)
3-9	N:A,B,B	(2-22) + (1-3)	(1-2) + (2-7)
3-10	F:A,B,B	(2-22) + (1-3)	(1-1) + (1-2) + (1-3)
3-11	M:B,A,D	(2-22) + (1-2)	(1-2) + (1-1) + (1-2)
3-12	F:B,A,D	(2-22) + (1-2)	(1-2) + (1-1) + (1-2)
3-13	M:D,A,B	(1-2) + (1-1) + (1-3)	(1-2) + (2-10)
3-14	F:D,A,B	(1-2) + (1-1) + (1-3)	(1-2) + (1-1) + (1-3)
3-15	M:A,D,A	(1-1) + (1-2) + (1-1)	(1-1) + (1-2) + (1-1)
3-16	F:A,D,A	(1-1) + (1-2) + (1-1)	(1-1) + (1-2) + (1-1)
3-17	C:A,D,A	(1-1) + (1-2) + (1-1)	(1-2) + (2-7)
3-18	C:D,A,B	(1-2) + (2-22)	(1-1) + (2-15)
3-19	C:B,A,D	(1-2) + (2-22)	(1-1) + (2-15)
3-20	C:A,B,B	Prime Equation	(1-2) + (2-7)
3-21	C:B,B,A	Prime Equation	(1-2) + (2-7)
3-22	C:A,D,D	(1-1) + (2-21)	VFR only
3-23	M:A,D,D	(1-1) + (1-2) + (1-2)	VFR only
3-24	F:A,D,D	(1-1) + (1-2) + (1-2)	(1-1) + (1-2) + (1-2)
3-25	C:D,A,D	(1-2) + (1-1) + (1-2)	(1-1) + (2-15)
3-26	M:D,A,D	(1-2) + (1-1) + (1-2)	(1-2) + (1-1) + (1-2)
3-27	F:D,A,D	(1-2) + (1-1) + (1-2)	(1-2) + (1-1) + (1-2)
3-28	C:D,D,D	Prime Equation	(2-15)
3-29	M:D,D,D	(2-21) + (1-2)	(1-2) + (1-2)

TABLE 2-1 (Cont.)

RUNWAY CAPACITY MODELS

Model No.	Separation Operation Per Runway	Model Logic Summary VFR	IFR
4	Four Parallel: Runway 1-2 & 3-4 are close parallels.		
4-1	M:D,A,D,A	(1-2) + (1-1) + (1-2) + (1-1)	(1-2) + (1-1) + (1-2) + (1-1)
4-2	F:D,A,D,A	(1-2) + (1-1) + (1-2) + (1-1)	(1-2) + (1-1) + (1-2) + (1-1)
4-3	M:A,D,D,A	(1-1) + (1-2) + (1-2) + (1-1)	(1-1) + (1-2) + (1-2) + (1-1)
4-4	F:A,D,D,A	(1-1) + (1-2) + (1-2) + (1-1)	(1-1) + (1-2) + (1-2) + (1-1)
4-5	M:A,D,D,B	(1-1) + (1-2) + (2-23)	(1-1) + (1-2) + (1-2) + (1-1)
4-6	F:A,D,D,B	(1-1) + (1-2) + (2-23)	(1-1) + (1-2) + (1-2) + (1-1)
4-7	M:D,A,D,B	(1-2) + (1-1) + (2-23)	(1-2) + (1-1) + (1-2) + (1-1)
4-8	F:D,A,D,B	(1-2) + (1-1) + (2-23)	(1-2) + (1-1) + (1-2) + (1-1)
4-9	M:B,A,A,D	(2-22) + (1-1) + (1-2)	(1-2) + (2-7) + (1-2)
4-10	F:B,A,A,D	(2-22) + (1-1) + (1-2)	(1-2) + (1-1) + (1-1) + (1-2)
4-11	M:B,A,D,A	(2-22) + (1-2) + (1-1)	(1-2) + (1-1) + (1-2) + (1-1)
4-12	F:B,A,D,A	(2-22) + (1-2) + (1-1)	(1-2) + (1-1) + (1-2) + (1-1)
4-13	M:B,B,A,D	(2-24) + (1-1) + (1-2)	(1-1) + (1-2) + (1-1) + (1-2)
4-14	F:B,B,A,D	(2-24) + (1-1) + (1-2)	(1-1) + (1-2) + (1-1) + (1-2)
4-15	M:B,A,D,B	(2-22) + (2-23)	(1-2) + (1-1) + (1-2) + (1-1)
4-16	F:B,A,D,B	(2-22) + (2-23)	(1-2) + (1-1) + (1-2) + (1-1)
4-17	M:B,B,A,B	(2-24) + (2-22)	(1-1) + (1-2) + (1-1) + (1-2)
4-18	F:B,B,A,B	(2-24) + (2-22)	(1-1) + (1-2) + (1-1) + (1-2)
4-19	M:B,B,B,B	(2-24) + (2-24)	(1-1) + (1-2) + (1-1) + (1-2)
4-20	F:B,B,B,B	(2-24) + (2-24)	(1-1) + (1-2) + (1-1) + (1-2)
4-21	M/F:D,A,D,D	(1-2) + (1-1) + (2-21)	(1-2) + (1-1) + (2-21)
4-22	M/F:A,D,D,D	(1-1) + (1-2) + (2-21)	(1-1) + (1-2) + (2-21)
4-23	M/F:D,A,A,D	(1-2) + (1-1) + (1-1) + (1-2)	(1-2) + (1-1) + (1-1) + (1-2)
4-24	M/F:D,D,D,D	(2-21) + (2-21)	(1-2) + (1-2)

TABLE 2-1 (Cont.)

RUNWAY CAPACITY MODELS

Model No.	Separation: Operation Per Runway	Model Logic Summary VFR	IFR
5	Two Open V		
5-1	D:D,D	(1-2)+(1-2)	(1-2)+(1-2) if A (2-15) not A
5-2	D:A,D	(1-1)+(1-2)	(1-1)+(1-2)
5-3	D:B,D	(1-3)+(1-2)	(1-3)+(1-2) if A (1-1)+(1-2) not A
5-4	C:A,D	(1-1)+(1-2)	(1-1)+(1-2)
5-5	C:B,A	(1-3)+(1-1)	(1-2)+(1-1)
6	Intersecting		
6-1	:A,D	Prime Equation	Prime Equation
6-2	:B,D	Max (6-2, 1-3)	Max (6-2,1-3)
7	Three Intersecting: 1 & 2 are parallel.		
7-1	C:A,D,D	(1-1)+(1-2)	(1-1)+(1-2)
7-2	M:A,D,D	(1-1)+(1-2)	(1-1)+(1-2)
7-3	C:B,B,D	(2-24)	(1-1)+(1-2)
7-4	M:B,B,D	(1-3)+(1-3)	(2-12)
10	Three Open V: 1 & 2 are close parallel.		
10-1	D:B,A,D	(2-22)+(1-2)	(1-2)+(1-1)+(1-2) if A (2-15)+(1-1) not A
10-2	D:B,B,D	(2-24)+(1-2)	(1-2)+(1-1)+(1-2) if A (2-15)+(1-1) not A
10-3	C:B,D,A	(2-23)+(1-1)	(1-1)+(1-2)
10-4	C:B,B,A	(2-24)+(1-1)	(1-1)+(1-2)
10-5	D:D,A,D	(2-20)+(1-2)	(2-20)+(1-2) if A (1-1)+(2-15) not A

For models 5, 10, 11, 12, 13 and 14

a) Before colon
   D = Diverging
   C = Converging

b) A
   Condition A exits if any of the following are true:
   (1) Angle--30 degrees
   (2) 15--angle--30 and separation--2000 ft.
   (3) Angle--15 and separation--3500 ft.

TABLE 2-1 (Cont.)

RUNWAY CAPACITY MODELS

Model No.	Separation: Operation Per Runway	Model Logic Summary: VFR	Model Logic Summary: IFR
11	Four Open V: 1 & 2 and 3 & 4 are close parallel.		
11-1	D:A,A,D,D	(2-19)+(2-21)	(1-1)+(1-2)
11-2	D:B,B,D,D	(2-24)+(2-21)	(1-1)+(1-2)+(1-2) if A (1-1)+(2-15) not A
11-3	C:A,A,D,D	(2-19)+(2-21)	(1-1)+(1-2)
11-4	C:B,B,D,D	(2-19)+(2-21)	(1-1)+(1-2)
12	Two Intersecting Beyond Threshold		
12-1	D:A,D	(1-1)+(1-2)	(1-1)+(1-2)
12-2	D:B,D	(1-3)+(1-2)	(1-3)+(1-2) if A (1-1)+(1-2) not A
12-3	C:D,A	(1-2)+(1-1)	(1-2)+(1-1)
12-4	C:B,A	(1-3)+(1-1)	(1-2)+(1-1)
13	Three Intersecting Beyond Threshold: 1 & 2 are close parallel.		
13-1	D:B,A,D	(2-22)+(1-2)	(1-2)+(1-1)+(1-2) if A (1-1)+(2-15) not A
13-2	D:B,B,D	(2-24)+(1-2)	(1-2)+(1-1)+(1-2) if A (1-1)+(2-15) not A
13-3	C:B,D,A	(2-23)+(1-1)	(1-1)+1-2)
13-4	C:B,D,A	(2-24)+(1-1)	(1-1)+(1-2)
14	Four Intersecting Beyond Threshold: 1 & 2 and 3 & 4 are close parallel.		
14-1	D:A,A,D,D	(2-19)+(2-21)	(1-1)+(1-2)
14-2	D:B,B,D,D	(2-24)+(2-21)	(1-2)+(1-1)+(1-2) if A (2-15)+(1-1) not A
14-3	C:A,A,D,D	(15-1)	(6-1)
14-4	C:B,B,D,D	(2-24)	(1-1)+(1-2)
15	Four Intersecting: 1 & 2 and 3 & 4 are close parallel.		
15-1	:A,A,D,D	Prime Equation	(6-2)
15-2	:B,B,D,D	Max (15-1, 2-24)	(1-1)+(1-2)

TABLE 2-1 (Cont.)

RUNWAY CAPACITY MODELS

DISTANCE THRESHOLD TO EXIT (000 Ft.)	WET RUNWAYS				DRY RUNWAYS							
					REGULAR EXITS				HIGH-SPEED EXITS			
	A	B	C	D	A	B	C	D	A	B	C	D
0	24	27	30	47	24	27	29	34	19	24	35	35
1	24	27	30	47	24	27	29	34	27	24	35	35
2	34	27	30	47	34	27	29	34	35	24	35	35
3	44	37	30	47	44	37	29	34	43	32	35	35
4	55	47	38	47	55	46	38	38	43	41	35	35
5	65	56	47	47	65	56	47	47	43	49	44	44
6	76	65	56	56	76	65	56	56	43	49	54	54
7	99	99	65	65	76	75	65	65	43	49	63	63
8	99	99	73	73	76	75	73	73	43	49	63	63
9	99	99	82	82	76	75	82	82	43	49	63	63
10	99	99	82	82	76	75	85	85	43	49	63	63
11	99	99	82	82	76	75	90	90	43	49	63	63

TABLE 2-2

ARRIVAL RUNWAY OCCUPANCY TIME (Seconds) - ARBAR2

DISTANCE THRESHOLD TO EXIT (000 Ft.)	WET RUNWAYS				DRY RUNWAYS							
					REGULAR EXITS				HIGH-SPEED EXITS			
	A	B	C	D	A	B	C	D	A	B	C	D
0	0	0	0	0	0	0	0	0	0	0	0	0
1	4	0	0	0	6	0	0	0	13	0	0	0
2	60	0	0	0	84	1	0	0	90	1	0	0
3	96	10	0	0	100	39	0	0	100	40	0	0
4	100	80	1	0	100	93	8	0	100	93	26	3
5	100	100	12	0	100	100	49	9	100	100	76	55
6	100	100	48	10	100	100	92	71	100	100	98	95
7	100	100	88	64	100	100	100	98	100	100	100	100
8	100	100	100	93	100	100	100	100	100	100	100	100
9	100	100	100	100	100	100	100	100	100	100	100	100
10	100	100	100	100	100	100	100	100	100	100	100	100
11	100	100	100	100	100	100	100	100	100	100	100	100

TABLE 2-3

EXIT UTILIZATION PERCENT - EXIPT

DISTANCE	AA	AB	AC	AD	BA	BB	BC	BD	CA	CB	CC	CD	DA	DB	DC	DD
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,000	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
2,000	17	17	17	17	8	8	8	8	5	5	5	5	5	5	5	5
3,000	32	32	32	32	37	37	37	37	24	24	24	24	19	19	19	19
4,000	32	32	32	32	40	40	40	40	38	38	38	38	35	35	35	35
5,000	32	32	32	32	40	40	40	40	47	47	47	47	47	47	47	47
6,000	32	32	32	32	40	40	40	40	51	51	51	51	55	55	55	55
7,000	32	32	32	32	40	40	40	40	51	51	51	51	58	58	58	58
8,000	32	32	32	32	40	40	40	40	51	51	51	51	58	58	58	58
9,000	32	32	32	32	40	40	40	40	51	51	51	51	58	58	58	58
10,000	32	32	32	32	40	40	40	40	51	51	51	51	58	58	58	58

TABLE 2-4

ARRIVAL-DEPARTURE SEPARATION REQUIREMENT (Seconds) - ADSR

DISTANCE	AA	AB	AC	AD	BA	BB	BC	BD	CA	CB	CC	CD	DA	DB	DC	DD
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 2-5

DEPARTURE-ARRIVAL SEPARATION REQUIREMENT (N.Mi.) - DICBR

CHAPTER 3 - ON-LINE RUNWAY CAPACITY MODEL VERSION 2 - RUNWAY CAPACITY

3.1 Introduction

The On-line Runway Capacity Model is an adaptation of the general analytic capacity model described in Chapter 2 for determining runway capacity. It employs a tutorial (question and answer) routine between the computer and user. The user enters a command to initialize the routine from a teletype terminal. Thereafter, the computer queries the teletype terminal for input data. The computer automatically checks input data to determine if they are in a valid format (e.g., the aircraft mix percentages must sum to 100%), and requests that new data be entered if the original data are invalid. The user supplied information is a subset of that required to use the Batch Capacity Model. The output of the On-line Runway Capacity Model is a summary of user supplied inputs and the calculated hourly capacity of the runways.

Access to the On-line Runway Capacity Model can be achieved with most teletype-compatible remote terminals which have telephone communications to a computer service offering the technique. Computer access is achieved by entering the appropriate user identification code and the appropriate program identification code (e.g., EX FAA). A current list of computer services offering the On-line Runway Capacity Model (with telephone number and appropriate program identification code) is available from:

Chief, Airport Design Branch, ARD-410
DOT/FAA
2100 Second Street, S.W.
Washington, D.C. 20590

(202) 426-3685

To utilize the On-line Runway Capacity Model to determine runway capacity, it is necessary to have a remote computer terminal and telephone connections with a computer service. It is not necessary to understand the details of computer operations or the Batch Capacity Model described in Chapter 2. Each user must establish his own user identification code with a computer service (or timesharing company) which offers the program and must pay for the computer time, connect time, storage cost and any other charge associated with his use of the model. Each computer service offering the program will have representatives available to explain the operation of remote computer terminals.

3.2 Discussion of Terms Used By the On-line Runway Capacity Model

a. Air Traffic Control System. The On-line Runway Capacity Model can utilize either current or future air traffic control systems. The first data request (Figure 3-3) is "DO YOU WANT A LISTING AND IMPLEMENTATION SCHEDULE OF FUTURE AIR TRAFFIC CONTROL SYSTEMS? (Y or N)." The answer to this question influences the selection of the arrival-arrival separation (DLTAIJ), departure-departure separation (TD), model number, SIGAA and PV. A report describing the use of the On-line Runway Capacity Model for assessing the effect of future air traffic control hardware performance on airport capacity and delay will be available at a later date. For additional information on this subject contact:

DOT/FAA
Director, Office of System Engineering Management
800 Independence Avenue, S.W.
Washington, D.C. 20590

b. Operating Condition. Operating conditions vary over a considerable range of applicable rules, procedures, conventions, and atmospheric ceiling/visibility. The On-line Runway Capacity Model considers three significantly different sets of operating conditions:

VFR (visual flight rules): Operations conducted with visual approach procedures.

IFR (instrument flight rules): Instrument operations conducted with visual separation procedures.

PVC (poor visibility conditions): Instrument operations conducted under the most strict observance of air traffic control separation standards.

As used in this chapter, three of the quantitative parameters that differentiate VFR, IFR and PVC are:

(1) Arrival-arrival separation,

(2) Departure-arrival separation, and

(3) Dependency between parallel runways.

In VFR, the average arrival-arrival separations over threshold are roughly equal to the published air traffic control criteria. This situation corresponds to a very tightly packed arrival stream. In IFR and PVC, some arrival-arrival separations (especially those for slow aircraft following fast aircraft) are increased to provide for all aircraft flying a 6 nautical mile common final approach path.

On any runway with both arrival and departure operations, inbound arrivals must be 2 nautical miles or more from the threshold before a departure can be cleared to roll in VFR, IFR

and PVC. On parallel runways with centerline separation over 700 feet, departures can be released irrespective of the location of an arrival on a parallel runway in VFR and IFR. In PVC, departures cannot be released unless an arrival on a parallel runway is more than 2 nautical miles from the threshold or the centerline separation between the parallel runways is 3,500 feet or more. On intersecting runways, the departure-arrival separation is a function of the distance from arrival threshold to intersection and the distance from departure threshold to intersection in VFR and IFR. In PVC, the arrival must be 2 n.mi. or more from the runway threshold when the departure starts to roll.

Simultaneous approaches are permitted on parallel runways in VFR. In IFR and PVC, simultaneous arrival approaches are permitted only on parallel runways spaced 4,300 feet or more on centerline. For parallel runways spaced between 4,299 and 2,500 feet, arrivals are staggered on parallel runways at the separation required for large jets. Below 2,500, no parallel approaches are permitted in IFR and PVC (i.e., the separation between arrivals on parallel runways are the same as if they were on a common approach path).

In all cases, two aircraft are not permitted to operate on a single runway simultaneously.

In calculating VFR, IFR and PVC capacities, special attention should be given to the relationship between the specified operating condition and the runway use configuration. It is possible to calculate VFR, IFR and PVC capacity for any of the runway use configurations shown in Figure 3-2. However, it may not be possible to conduct saturation operations on all runways for some operating conditions. For example, mixed operations can be conducted on close parallel runways in VFR operating conditions. In IFR, they cannot. If mixed operations are specified on close parallel runways in IFR, the program will automatically convert this specification to arrivals only on one runway and departures only on the other. This process, which reflects the results of extensive analysis of the air traffic control system, is true for many runway use configuration/operating condition combinations. Therefore, specify the runway use configuration which most closely agrees with what can actually happen under the desired operating condition.

c. Runway Use Configuration. Figure 3-2 identifies a series of runway use configurations, the number assigned to each runway, and the additional data required for some runway use configurations. These additional data include the separation distance between parallel runways, the distance from threshold to intersection, the distance between the centerline of runway number one and the threshold of the far nonparallel runway, and the angle between nonparallel runways. All distances are in feet and the angle is in degrees.

If a particular runway use configuration is not included in Figure 3-2, it may be possible to divide the runway use configuration into independent components. If a very small percent of the total arrivals or departures is expected to occur on a given runway, it may be realistic to omit it in the specification of runway use configuration. These methods will often permit the runway use configuration to be found in Figure 3-2.

A number of assumptions are built into the runway use configurations contained in Figure 3-2.

(1) For two intersecting runways, the runways are assumed to be independent if the arrival intersection distance is equal to or greater than 8,000 feet.

(2) For three parallel runways, the centerline separation between the outer runways is assumed to be related to the separation between the inner runways in the following manner:

S	C + S
700 - 2499	2500 - 3499
2500 - 3499	3500 - 4299
3500 - 4299	4300 or more
4300 or more	4300 or more

where: S is the input separation between a pair of runways, and C is the fixed separation between a pair of runways.

(3) For four parallel runways, the separation between the inner parallel runways is assumed to be 3500 feet or greater.

d. Aircraft Mix. In general, aircraft mix is assigned by runway. It represents the population of aircraft that will use that particular runway, not necessarily the airport as a whole. However, for the following diagram numbers, input only one aircraft mix which is representative of the aircraft population on all runways (i.e., the airport mix).

VFR: 25, 26, 27, 28

IFR and PVC: 12, 25, 26, 27, 28, 33, 35, 37, 38, 44, 46 and 50

Frequently, the aircraft mix will only be known for the total airport and not by runway. If all runways are used by all aircraft types in the same proportions, use the airport mix on

each runway. If there is segregation of aircraft types on certain runway(s), the aircraft mix by runway will have to be established. The capacity results will then reflect the aircraft mix by runway and not the overall airport mix.

Aircraft mix by runway is determined by first calculating the demand by aircraft class for the airport; i.e., the total airport demand times the mix percents. Based on the site specific conditions of the runways, the demand by aircraft class is allotted to each runway. The aircraft mix by runway is then computed based on the aircraft demand using each runway. <u>When the runway mixes are not identical, Demand-Capacity comparisons for the airport should be made by aircraft class.</u> If the demand of a particular aircraft class is greater than its capacity, it may be possible (depending on site specific conditions) that the aircraft class demand by runway could be adjusted such that the capacity for that aircraft class; i.e., the runway capacity times the runway mix percent, is increased. This action should be considered if the demand for a particular aircraft class is greater than its capacity.

e. <u>Exit Type</u>. Two types of exit taxiways are available:

(1) <u>Angled Exits</u>. Angled exits (also known as high-speed exits) are those where aircraft may exit at velocities from 30 to 60 miles per hour to reduce runway occupancy time. If an exit is not used in this manner, no matter what its geometry, it should not be considered as an angled exit for purposes of determining runway capacity.

(2) <u>Standard Exits</u>. Standard exits include all other exits. Standard exits are referred to as "other exits" in AC 150/ 5335-1A "Airport Design Standards - Airports Served By Air Carrier - Taxiways."

For the On-line Runway Capacity Model, it is assumed that all exits are equally desirable and that all exits are located on the same side of the runway. The capacity model described in Chapter 2 should be used to study the effect of preferential airline exiting or exits located on both sides of a runway. It is also assumed that each runway has an entrance and exit located at the ends of the runway.

3.3 <u>Data Requests</u>

There are several ways to use the On-line Runway Capacity Model. The basic approach corresponds to answering the questions as they appear. However, there are many options available to shorten the time required to enter data or to enter more data than is readily apparent. The following is a detailed description of the questions asked by the On-line Runway Capacity Model and all possible use options.

DO YOU WANT A LISTING AND IMPLEMENTATION SCHEDULE FOR FUTURE ATC SYSTEMS?

This data request is made immediately after the program identification code is entered (e.g., EX FAA). This question is not repeated if capacity is calculated for additional runway configurations. The most current description of future air traffic control systems will be printed if a "yes" response is given to this data request.

Actually, three "yes" or "no" answers can be given at this point (although the second two are not mandatory). The first is for the question as asked. The second is for "Do you want the long form of the data request?" A "no" answer will result in abbreviated data requests being made. A comparison of the long and abbreviated forms of the questions is contained in Figure 3.4. The third is for "Do you want an input summary?" A "no" will result in no input summary being printed after the input data is entered. Any sequence of "yes" and "no" entries, separated by spaces, is permitted. A "yes" is assumed for the second and third questions unless a "no" is entered.

ENTER PRESENT OR FUTURE ATC CONFIGURATION (P F1 F2 G3 H4).

This data request is always made. The future air traffic control systems F1, F2, G3 and H4 are identified in the list of future air traffic control systems. F1, F2, G3 and H4 are standard inputs. However, there are 102 possible answers to this question. The answer is composed of two parts; i.e., the ATC letter and the ATC number. For example, F2 is for ATC letter F and ATC number 2. The ATC letters are primarily concerned with lateral separation for parallel runways. The ATC number is primarily concerned with the longitudinal separations used.

The following defines all possible ATC letters:

P & F Present (i.e., April 1976) lateral separations as defined in the Air Traffic Control Handbook.

G Present lateral separations without lateral wake turbulence separation.

J Independent arrivals at 3500 feet.

I Independent arrivals and departures at 2500 feet.

H Independent arrivals at 3500 feet and no lateral wake turbulence separations.

The ATC numbers are defined as:

0 Present air traffic control system using PMM input data.

1 Basic meteorological advisory system to overcome wake turbulence separation using a combination of PMM and MITRE input data.

2 Add basic metering and spacing to wake vortex prediction using a combination of PMM and MITRE input data.

3 Add MLS and improved surveillance to ATC number 2 using a combination of PMM and MITRE input data.

4 Add DABS and reduced missed approach zones to ATC number 3 using a combination of PMM and MITRE input data.

5 Fallback position for ATC number 1.

6 Fallback position for ATC number 2.

7 Fallback position for ATC number 3.

8 Fallback position for ATC number 4.

9 Present ATC system using MITRE inputs.

10 Same as ATC letter 1, but using MITRE inputs.

11 Same as ATC letter 2, but using MITRE inputs.

12 Same as ATC letter 3, but using MITRE inputs.

13 Same as ATC letter 4, but using MITRE inputs.

14 Pre-November 15, 1975, ATC rules using PMM inputs.

15 Same as ATC number 14.

X A special code that allows the user to enter values for DLTAIJ, SIGAA, and PV. Also, DA for two intersecting runways.

Any combination of ATC letter and ATC number can be input.

ENTER VFR, IFR, OR PVC.

This data request is always made. Acceptable answers are: VFR or V; IFR or I; PVC or P.

The present operating condition defined by MITRE as IFR Limiting Case can be studied by entering P9 for the ATC

configuration question and PVC for this question. IFR Limiting Case (LIFR) is defined as instrument operations conducted under the most strict observance of air traffic control spacing minimums.

DO GA AIRCRAFT FLY A SHORT FINAL APPROACH?

This question is only asked for VFR operating conditions. A "no" response will result in the assumption that all aircraft fly a 6 nautical miles common approach path. A "yes" response will result in the assumption that class A and B aircraft fly a 1 nautical mile common approach path. As an option, the letter "q" can be entered. This will result in the additional question: INPUT GAMA? The user can then enter the length of the common approach path in nautical miles for each aircraft class (i.e., A, B, C, D).

ENTER RUNWAY USE DIAGRAM NUMBER (1-51).

This request is always made. Figure 3-2 illustrates the 51 runway use diagrams used by the On-line Runway Capacity Model.

ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D) FOR EACH PRINTED RUNWAY NUMBER.

This information request is made for every runway in the runway use diagram. Runway numberes are given in Figure 3-2. Enter a "0" to denote that the aircraft mix does not include a particular aircraft class.

If each runway has the same aircraft mix, enter "All" after the mix percentage for the first runway (e.g., 0 7 63 30 All). The input must be four integers which sum to 100.

ENTER SEPARATION "S" BETWEEN PARALLEL RUNWAYS (FEET).

This data request is made for runway use diagrams 2 thru 12 Enter this separation in feet.

ENTER DISTANCE "X" BETWEEN THRESHOLD AND INTERSECTION FOR EACH PRINTED RUNWAY NUMBER (FEET).

This request is made for runway use diagrams 23 through 26 by runway. Runway numbers are given in Figure 3-2. This distance is measured in feet from the threshold (in the direction of operations) to the intersection point.

ENTER ANGLE "A" BETWEEN NONPARALLEL RUNWAYS (DEGREES).

This data request will be made for runway use diagrams 31, 33, 35, 39, 42, 44, 46 and 50. The angle must be greater than 0 and less than 90 degrees.

ENTER DISTANCE "D" BETWEEN THE THRESHOLD AND CENTERLINE OF NONPARALLEL RUNWAY (FEET).

This request is made for the same runway use diagrams as the angle A. For runway use diagram 31 and 42, the distance is from the threshold of runway 2 to the centerline of runway 1. For all other runway use diagrams (i.e., 33, 35, 39, 44, 46, and 50) it is from the threshold of runway 3 to the centerline of runway 1. Enter this distance in feet.

ENTER ARRIVAL PERCENTAGE.

This data request is made for all runway use configurations. Enter arrival percentage as an integer from 0 to 100. The On-line Runway Capacity Model can be used to determine the maximum number of arrivals and departures per hour that can use the runway(s) when arrivals have first priority. It is obtained by entering the special code 9999 as the arrival percentage. For single and two intersecting runways (i.e., diagram nos. 1 and 23), it is possible to obtain the 50% arrival capacity that gives equal priority to arrival and departure operations. This is done by entering "50, EP.".

ENTER TOUCH-AND-GO PERCENTAGE.

This data request is made in VFR weather for single or parallel runways. It is assumed that there are no touch-and-go operations in IFR or PVC. Enter an integer between 0 and 100.

ENTER EXIT DISTANCES AND RUNWAY LENGTH (FEET) FOR EACH PRINTED RUNWAY NUMBER. IDENTIFY HIGH-SPEED EXITS WITH A "H" AFTER DISTANCE. ENTER "W" AFTER RUNWAY LENGTH TO IDENTIFY WET RUNWAY.

This data request is made for every arrival runway in the runway use configuration. The runways are numbered in Figure 3-2. Exit distances must be positive integers entered in ascending order. Exit distances can be specified to the nearest 100 foot. Any exit distance greater than 11,000 feet will be considered to be at 11,000 feet. The letter "H" can be entered immediately after a runway exit distance (e.g., 4210a) to identify an angled exit. The letter "W" can be entered one space after the runway length of runway number one to identify wet runways (e.g., 3250 4625 5430H 6710 10413 W). If exit locations are unknown or not considered important for the particular application of the On-line Runway Capacity Model, it

is possible to enter the letter "S" as the exit location for each runway; this is equivalent to entering "2000 3000 4000 5000 6000 7000 9000."

In addition to all of the above, the word STOP can be entered for any data request if the user wished to terminate the tutorial sequence of questions. The next question will be, "DO YOU WISH TO PERFORM ANOTHER CALCULATION?"

3.4 Output

Immediately after the exit data is entered, the teletype terminal will type an input summary. This summary defines the input data supplied by the user for calculating hourly runway capacity. The input summary does not contain any error messages and can serve as a permanent record of inputs used for the calculation.

The input summary will contain a warning message if the runway length is too short for any of the aircraft classes which use it. The warning message will state that the runway length may not be adequate for some aircraft if the input runway length is slightly below the normal runway length for any aircraft class present in the mix; i.e., whose mix percent is not zero. The warning message will define the runway length used if the input runway length is significantly below the normal runway length.

The total hourly capacity of the runway use configuration and the number of arrivals and departures is typed after the input summary. For future air traffic control systems and runway use diagram nos. 1, or 23 (single and two intersecting) the runway capacity is printed for the standard procedure to consider arrival percentage and a technique where arrivals are optimally spaced to allow the desired number of operations.

DO YOU WISH TO PERFORM ANOTHER CALCULATION?

This question is asked <u>after</u> the remote terminal prints the hourly runway capacity. A response of "y" or "yes" will start the data request sequence with ENTER PRESENT OR FUTURE ATC CONFIGURATION (P F1 F2 G3 H4). Any other response will automatically terminate the access to the On-line Runway Capacity Model.

The On-line Runway Capacity Model prepares a data file for each run in conformance with the format specifications for the Batch Capacity Model contained in paragraph 2.3. This file can be listed after each run, if desired, to see exactly what built-in data was used to make the run. The procedure is:

- Respond with a "no" to "DO YOU WISH TO MAKE ANOTHER CALCULATION?"

o Type the executive level command:

L INPUT.DATA on McAuto, or
TYPE OUTPUT.DATA on TYMSHARE.

After the data is printed, the user can reload the On-line Runway Capacity Model by entering EX FAA.

NOTE: The data file created by the On-line Runway Capacity Model is erased after each run of the model. Therefore, the data used for a run can only be printed before another run is executed.

To compute hourly delays, Figure 2-68 in reference b can be used. The procedure for computing hourly delay is explained in paragraphs 27 and 28 of that report. The delay factors ADF and DDF should be calculated using Appendix D for future ATC environments.

3.5 Model Variations

It is expected that from time to time changes will be made to the On-line Runway Capacity Model to add or delete capabilities, to modify air traffic control procedures, or to revise aircraft operational parameters. Whenever a change is made to the On-line Runway Capacity Model, the version number will be changed. The version number is recorded on the second line of the printed computer dialogue.

The examples included in this chapter have been solved using On-line Runway Capacity Model Version 2. They illustrate the procedure for determining runway capacity and show how capacity fits into the total airport planning process. When a version number is changed, the user may not be able to duplicate the exact capacity results shown in the examples. The user should be aware of the current version number. Only the current version of the On-line Runway Capacity Model will be available from the computer service bureaus. A description of each version will be available from the Chief, Airport Design Branch (ARD-410). On-line Runway Capacity Model Version 2 is based on the air traffic control procedures found in 7110.65, "Air Traffic Control Handbook," dated April 1976.

The output of the On-line Runway Capacity Model lists the "Batch" Capacity Model version number. This number is related to the form of the capacity model used when the complete input scenario discussed in Chapter 2 is made with punched cards. The Batch Capacity Model version number has no bearing on the use of the On-line Runway Capacity Model.

3.6 Sensitivity Analysis

To facilitate the production of sensitivity analysis, the following files have been created on TYMSHARE and McAuto:

COMMAND FILE McAuto	COMMAND FILE TYMSHARE	CONDITION
EX VFRPA	VFRPA EXEC	Percent Arrivals in VFR
EX IFRPA	IFRPA EXEC	Percent Arrivals in IFR or PVC
EX TG	TG EXEC	Percent Touch-and-Go Operations
EX FAR	FAR EXEC	All Runway Use Strategies Applicable For Spaced Parallel Runways
EX MED	MED EXEC	All Runway Use Strategies Applicable For Medium Spaced Parallel Runways
EX NEAR	NEAR EXEC	All Runway Use Strategies Applicable For Near Spaced Parallel Runways
EX CLOSE	CLOSE EXEC	All Runway Use Strategies Applicable For Close Spaced Parallel Runways

The command files VFRPA and IFRPA produce capacity results for 0, 35, 50, 65, 100 percent arrivals and 9999.

The command file Touch-and-Go produces capacity results for 10, 20, 30, 40, 50 and 60 percent touch-and-go.

The command files FAR, MED, NEAR, and CLOSE produce capacity results for the following runway use strategies:

Runway Use Strategy Runway 1	Runway Use Strategy Runway 2
A	A
A	D
D	D
A/D	A
A/D	D
A/D	A/D

where:

A = Arrival   D = Departure   A/D = Arrival & Departure

The procedure is to first make a run of the On-line Runway Capacity Model for the desired conditions. Then enter "no" to the question "DO YOU WISH TO MAKE ANOTHER CALCULATION?" From the executive level, enter one of the above command files to produce the desired sensitivity analysis.

3.7 Examples

The following examples illustrate the use of the On-line Runway Use Configuration Version 2:

Example 1

Determine the saturation hourly capacity without regard to per-

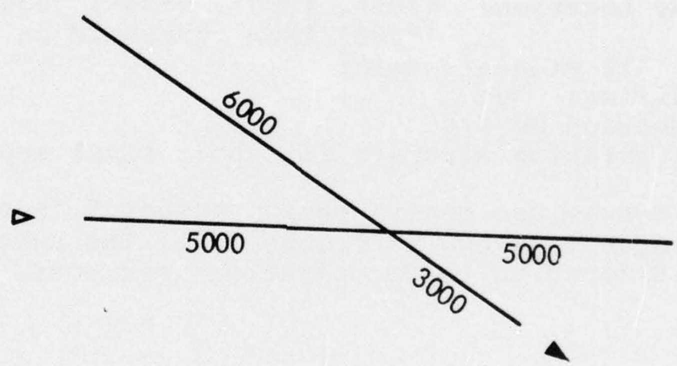
cent arrival of a single runway in PVC operation conditions.

Aircraft Mix: 0%A, 5%B, 75%C, 20%D
Percent Arrival: 9999
Percent Touch-and-Go: 0
Exit Taxiway Location: 4300', 5100', 5700', 6400'
7500' and 9300' from arrival threshold
Exit Type: All standard exits
Runway Condition: Dry

From Figure 3-2, runway use configuration number 1 is selected. The computer dialogue is shown in Figure 3-5. The saturation hourly capacity is found to be 47.7 operations/hour. The percent arrival is found to be 71.8.

Example 2

Determine the saturation hourly capacity of the runway use configuration shown below in VFR operation conditions assuming that arrival and departure operations have equal priority for use of the runway.



Aircraft Mix: 0%A, 5%B, 50%C, 45%D
Percent Arrival: 50, EP
Percent Touch-and-Go: 0
Exit Taxiway Location: Assume good exiting; i.e., S
Exit Type: All standard exits
Runway Condition: Dry
Arrival-Arrival Separation:

DLTAIJ:	2	2	2	2
	2	2	2	2
	2	2	2	2
	2	2	2	2

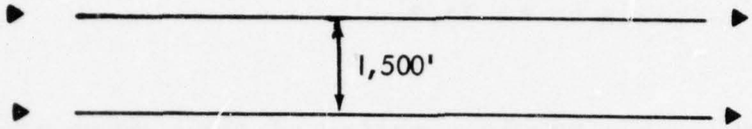
SIGMAA = 8 seconds
Probability of violation = .09
All general aviation aircraft conduct short final approaches.

Approach Speed: 95, 120, 130, 140

From Figure 3-2, runway use configuration number 23 is selected. The computer dialogue is shown in Figure 3-6. The hourly capacity when arrival and departure operations have equal priority is found to be 60 operations per hour. (Note: Only 49 operations per hour are possible with preemptive arrival priority.)

Example 3

Determine the saturation hourly capacity of the runway use configuration shown below in VFR operation conditions.



Aircraft Mix: 0%A, 0%B, 50%C, 50%D
Percent Arrival: 60
Exit Taxiway Location: 4100', 4900', 5500', 7000' and 10000' from threshold on both runways
Exit Type: All standard exits
Runway Condition: Wet
Percent Touch-and-Go = 0
All general aviation aircraft fly short final approaches.

From Figure 3-2, runway use configuration number 5 is selected. The computer dialogue is shown in Figure 3-7. The saturation hourly capacity is found to be 86 operations per hour.

Example 4

Determine the sensitivity of saturation hourly capacity to percent arrivals for the following conditions:

Runway Use Configuration: 2
Weather: VFR
Aircraft Mix: 10%A, 10%B, 50%C, 30%D
Exit Taxiway Location: S
Runway Separation = 1000 feet
Percent Touch-and-Go = 0
All general aviation aircraft fly short final approaches.

The computer dialogue for this case is shown in Figure 3-8. The sensitivity of capacity to percent arrivals is found to be:

Hourly Capacity	Percent Arrival
58	0
90	35
90	50
85	65
68	100
81	9999; i.e., %arrivals = 85

REQUIRED DATA

1. Runway Use Configuration Code Number
2. Operating Condition (VFR, IFR, LIFR)
3. ATC Condition (Present or Future)
4. Aircraft Mix (%A, %B, %C, %D)
5. Percent Arrivals
6. Exit Locations
7. Do General Aviation aircraft fly short final approaches?
8. Percent Touch-and-Go Operations

SPECIAL GEOMETRY DATA FOR SOME CONFIGURATIONS

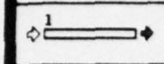
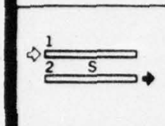
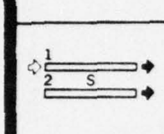
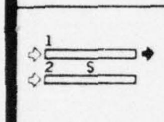
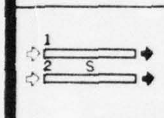
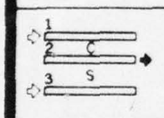
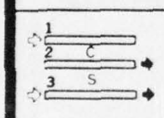
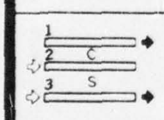
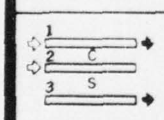
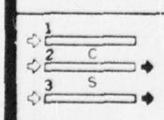
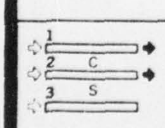
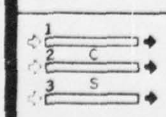
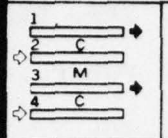
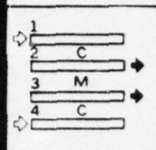
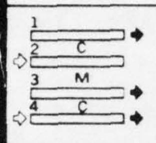
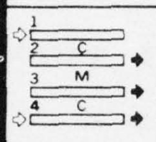
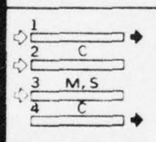
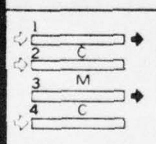
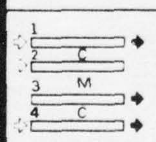
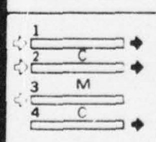
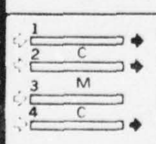
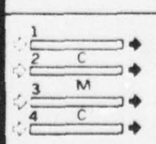
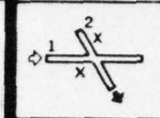
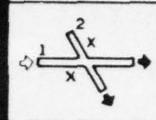
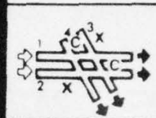
9. Centerline Separation
10. Intersection Distances
11. Angle Between Runways
12. Distance From Centerline of One Runway to Threshold of Another Runway

OPTIONAL DATA

13. Arrival-Arrival Separation
14. SIGAI
15. Probability of Violation
16. Departure-Arrival Separation
17. Length of Common Approach Path

FIGURE 3-1

ON-LINE INPUTS

RUNWAY USE DIAGRAM	DIAG. NO.	ADDITIONAL DATA
	1	
	2	S
	3	S
	4	S
	5	S
	6	S
	7	S
	8	S
	9	S
	10	S
	11	S
	12	S
	13	
	14	
	15	
	16	
	17	S
	18	
	19	
	20	
	21	
	22	
	23	X,X
	24	X,X
	25	X,X,X,X
	26	X,X,X,X

LEGEND:

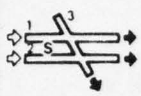
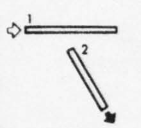
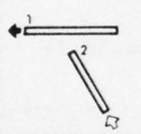
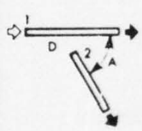
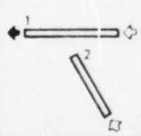
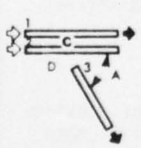
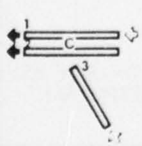
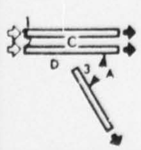
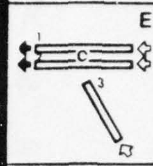
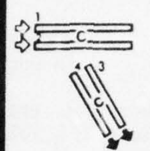
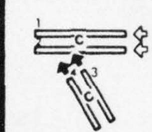
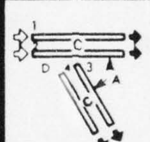
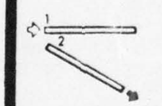
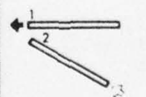
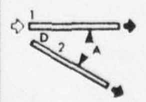
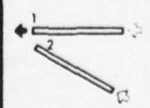
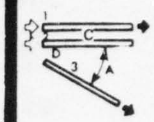
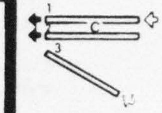
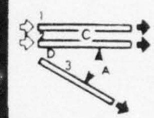
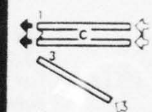
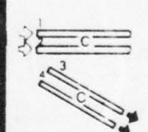
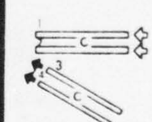
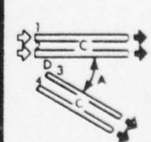
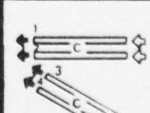
- ◇ Indicates that an arrival (or landing) may occur on the runway indicated.
- ◆ Indicates that a departure (or takeoff) may occur on the runway indicated.

The lack of a symbol means that aircraft operations will not or cannot occur from the runway indicated.

- S Indicates a variable runway spacing (feet).
- C Indicates runway spacing category 700-2499 feet.
- X Indicates distance from threshold to intersection (feet).
- A Indicates the angle between nonparallel runways (degrees).
- D Indicates distance from centerline of runway 1 to threshold of far non-parallel runway (feet).
- M Indicates runway spacing over 3500 feet.

RUNWAY USE CONFIGURATIONS FOR ON-LINE CAPACITY MODEL

FIGURE 3-2

RUNWAY USE DIAGRAM	DIAG. NO.	ADDITIONAL DATA
	27	S
	28	S
	29	
	30	
	31	D,A
	32	
	33	D,A
	34	
	35	D,A
	36	
	37	
	38	
	39	D,A
	40	
	41	
	42	D,A
	43	
	44	D,A
	45	
	46	D,A
	47	
	48	
	49	
	50	D,A
	51	

RUNWAY USE CONFIGURATIONS FOR ON-LINE CAPACITY MODEL

FIGURE 3-2 (Cont.)

DATA REQUEST	APPLICABILITY OF DATA REQUEST	VALID INPUT	MESSAGE FOR INVALID DATA
DO YOU WANT A DESCRIPTION AND IMPLEMENTATION SCHEDULE FOR FUTURE ATC SYSTEMS?	After accessing computer	y or n	Any response other than "n" is treated as a yes reply.
ENTER PRESENT OR FUTURE ATC SYSTEM (P F1 F2 G3 H4)	Always used	p,f1,f2 g3, or h4	ERR: INCORRECT ATC SYSTEM
ENTER VFR, IFR, OR PVC	Always used	v, i, or p	ERR: MUST BE VFR, IFR, OR PVC
DO GA AIRCRAFT FLY A SHORT FINAL APPROACH?	VFR only	y or n	ERR: ANSWER MUST BE YES OR NO
ENTER RUNWAY USE DIAGRAM NUMBER (1-51)	Always used	Integer 1 thru 51	ERR: RUNWAY USE DIAGRAM NUMBER MUST BE BETWEEN 1 & 51
ENTER AIRCRAFT MIX PERCENT CLASS A B C D) FOR EACH PRINTED RUNWAY NUMBER 1- 2- 3- 4-	For all runways in the runway use diagram	Four integers which sum to 100. Use the same mix for all runways.	ERR: MIX PERCENTAGES DO NOT TOTAL 100 FOR RUNWAY ___ REENTER
ENTER SEPARATION "S" BETWEEN PARALLEL RUNWAYS (FEET)	R/W Use Diag. 2-12,17,27,28	Integer	The data request is repeated if the entry isn't an integer.
ENTER DISTANCE "X" BETWEEN THRESHOLD AND INTERSECTION FOR EACH PRINTED RUNWAY NUMBER (FEET) 1 2 3 4	R/W Use Diag. 23,24,25,26. For all runways.	Integer under 10000	ERR: THRESHOLD TO INTERSECTION DISTANCE MUST BE AN INTEGER BETWEEN 0 & 9999
ENTER ANGLE "A" BETWEEN NONPARALLEL RUNWAYS (DEGREES)	R/W Use Diag. 31,33,35,39, 42,44,46,50	Integer 1 thru 90	ERR: ANGLE MUST BE AN INTEGER BETWEEN 1 & 90
ENTER DISTANCE "D" BETWEEN THE THRESHOLD AND CENTERLINE OF NONPARALLEL RUNWAY (FEET)	R/W Use Diag. 31,33,35,39, 42,44,46,50	Integer	The data request is repeated if the entry isn't an integer.
ENTER PERCENT ARRIVALS	Always used	Integer 0 thru 100	ERR: PERCENTAGE MUST BE AN INTEGER BETWEEN 0 & 100
ENTER PERCENT TOUCH AND GO	VFR only	Integer less than 2(% Arrivals) and 2(100-% Arrivals)	ERR: PERCENTAGE MUST BE AN INTEGER BETWEEN 0 & ___
ENTER EXIT DISTANCES AND RUNWAY LENGTH (FEET) FOR EACH PRINTED RUNWAY NUMBER. IDENTIFY HIGH SPEED EXITS WITH AN "H" AFTER DISTANCE. ENTER "W" AFTER RUNWAY LENGTH TO IDENTIFY WET RUNWAY 1 2 3 4	Based on runway use diag.	Integers in ascending order, separated by a space. An 'h' can be entered after any number of exits. A 'w' after no. 1 runway length identifies wet runways.	ERR: EXIT DISTANCES MUST BE POSITIVE INTEGERS ENTERED IN ASCENDING ORDER. ERR: EXIT ___ IS TREATED THE SAME AS THE PREVIOUS EXIT, NO TWO EXITS MAY BE THE SAME. REENTER.
DO YOU WISH TO PERFORM ANOTHER CALCULATION?	After output	y or n	Program automatically terminates for any entry except "y."

SUMMARY OF INPUTS FOR ON-LINE RUNWAY CAPACITY MODEL VERSION 2

FIGURE 3-3

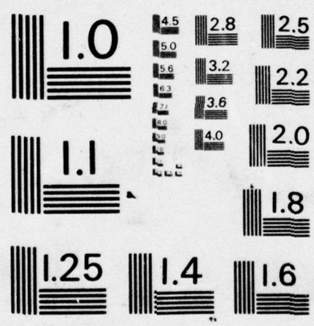
Full Data Request	Abbreviated Data Request
ENTER ATC SYSTEM CODE (P, F1, F2, G3, H4)	ATC
ENTER VFR, IFR OR PVC WEATHER	WEATHER
DO GA AIRCRAFT FLY A SHORT FINAL APPROACH? (Y OR N)	SHORT GA FINAL?
ENTER RUNWAY USE DIAGRAM NUMBER (1 THRU 51)	R/W No.
ENTER SEPARATION "S" BETWEEN PARALLEL RUNWAYS (FEET)	SEPARATION S
ENTER DISTANCE "X" BETWEEN THRESHOLD AND INTERSECTION FOR EACH PRINTED RUNWAY NUMBER (FEET)	THRESHOLD TO INTERSECTION X
ENTER DISTANCE "D" BETWEEN THE THRESHOLD AND CENTERLINE OF NONPARALLEL RUNWAY (FEET)	THRESHOLD TO NONPARALLEL D
ENTER ANGLE "A" BETWEEN NONPARALLEL RUNWAYS (DEGREES)	ANGLE A
ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D) FOR EACH PRINTED RUNWAY NUMBER	R/W MIX
ENTER ARRIVAL PERCENTAGE	ARRIVAL %
ENTER TOUCH-AND-GO PERCENTAGE	T & G %
ENTER EXIT DISTANCE AND RUNWAY LENGTH (FEET) FOR EACH PRINTED RUNWAY NUMBER	EXITS
DO YOU WISH TO PERFORM ANOTHER CALCULATION?	ANOTHER CALCULATION?

FIGURE 3-4

FULL AND ABBREVIATED DATA REQUESTS

AD-A033 685 FEDERAL AVIATION ADMINISTRATION WASHINGTON D C SYSTE--ETC F/G 1/5
MODEL USER'S MANUAL FOR AIRFIELD CAPACITY AND DELAY MODELS. BOO--ETC(U)
NOV 76 C T BALL
UNCLASSIFIED FAA-RD-76-128-BK-1 NL

2 OF 4
AD
A033685



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

COMPUTER DIALOGUE FOR EXAMPLE 1
FIGURE 3-5

```
EX FAA2

              *** AIRFIELD HOURLY CAPACITY MODEL ***
                      ON-LINE  VERSION 2

DO YOU WANT A LISTING AND IMPLEMENTATION
SCHEDULE OF FUTURE ATC SYSTEMS?
no

ENTER PRESENT OR FUTURE ATC SYSTEM  (P F1 F2 G3 H4)
p

ENTER VFR, IFR, OR PVC
pvc

ENTER RUNWAY USE DIAGRAM NUMBER (1 - 51)
1

ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D)
FOR EACH PRINTED RUNWAY NUMBER
1-
0 5 75 20

ENTER ARRIVAL PERCENTAGE
9999

ENTER EXIT DISTANCES AND RUNWAY LENGTH
(FT) FOR EACH PRINTED RUNWAY NUMBER. IDENTIFY
HIGH SPEED EXITS WITH AN "H" AFTER DISTANCE.
ENTER W AFTER RUNWAY LENGTH TO IDENTIFY WET RUNWAY.
1-
4300,5100,5700,6400,7500,9300

        *** INPUT SUMMARY ***
          ON-LINE VERSION 2

        P 0 ATC SYSTEM
        PVC  WEATHER
        DRY RUNWAY
        RUNWAY USE DIAGRAM #  1
      9999 PERCENT ARRIVALS
        0 PERCENT TOUCH & GO
R/W    AIRCRAFT    MIX     TYPE
 #     %A   %B   %C   %D   OPN    EXIT LOCATIONS (FT)

 1     0.   5.  75.  20.   BOTH   4300   5100   5700   6400   7500   9300
```

```
SINGLE RUNWAY MIXED OPERATIONS WITHOUT T & G

BATCH CAPACITY PROGRAM, VERSION 5
ARRIVALS 1ST PRIORITY & DEPARTURES 2ND PRIORITY WITHOUT REGARD TO PERCENTAGE
 ARRIVALS

             ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***


             TOTAL =     47.7  ARRIVAL =     34.2  DEPARTURE =     13.4


DO YOU WISH TO PERFORM ANOTHER CALCULATION?
no
```

FIGURE 3-5 (Cont.)

COMPUTER DIALOGUE FOR EXAMPLE 2
FIGURE 3-6

```
ex faa2

             *** AIRFIELD HOURLY CAPACITY MODEL ***
                       ON-LINE  VERSION 2

DO YOU WANT A LISTING AND IMPLEMENTATION
SCHEDULE OF FUTURE ATC SYSTEMS?
no no
ATC
px
WEATHER
vfr
SHORT FINAL ?
yes
R/W #
23
R/W MIX
1-
0,5,70,45

ERR: MIX PERCENTAGE DOES NOT TOTAL 100 FOR RUNWAY # 1
REENTER
1-
0,5,50,45
2-
0 5 50 45
THRESHOLD TO INTERSECTION X
1-
5000
2-
6000

ENTER DLTAIJ
2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2

ENTER SIGMAA
8

ENTER PV
.09

ENTER APPROACH SPEEDS
95,120,130,140
ARRIVAL %
50,ep
EXITS
1-
s
```

```
*** INPUT SUMMARY ***
  ON-LINE VERSION 2

P99 ATC SYSTEM
VFR  WEATHER
DRY RUNWAY
RUNWAY USE DIAGRAM # 23
50 PERCENT ARRIVALS
 0 PERCENT TOUCH & GO
DISTANCES BETWEEN THRESHOLDS AND INTERSECTION    5000    6000
DLTAIJ =  2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0
SIGMAA =  8.00
PV     =  0.09

R/W   AIRCRAFT    MIX    TYPE
 #    %A  %B  %C  %D     OPN     EXIT LOCATIONS (FT)

 1     0.  5. 50. 45.    ARR     2000  3000  4000  5000  6000  7000  9000
 2     0.  5. 50. 45.    DEP


TWO INTERSECTING, ARR ON #1, DEP ON #2

BATCH CAPACITY PROGRAM, VERSION 5
TO OBTAIN  50 PERCENT ARR, GAPS IN ARRIVAL STREAM MUST EXIST DURING  52
 PERCENT OF THE HOUR

          ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***


          TOTAL =    48.5  ARRIVAL =    24.2  DEPARTURE =    24.2


IDEAL SEPARATIONS WITH 16 VALUES OF DLTAIJ WITH AT LEAST 1 CLASS D DEPARTURE IN
TWO INTERSECTING, ARR ON #1, DEP ON #2
 2.9 3.2 3.3 3.4 2.9 3.4 3.5 3.6 3.1 3.6 3.8 4.0 3.2 3.8 3.6 4.2  TOTAL =  60.1
DO YOU WISH TO PERFORM ANOTHER CALCULATION?
no
```

FIGURE 3-6 (Cont.)

COMPUTER DIALOGUE FOR EXAMPLE 3
FIGURE 3-7

```
ex faa2

            *** AIRFIELD HOURLY CAPACITY MODEL ***
                     ON-LINE  VERSION 2

DO YOU WANT A LISTING AND IMPLEMENTATION
SCHEDULE OF FUTURE ATC SYSTEMS?
no yes no

ENTER PRESENT OR FUTURE ATC SYSTEM  (P F1 F2 G3 H4)
p

ENTER VFR, IFR, OR PVC
v

DO GA AIRCRAFT FLY A SHORT FINAL APPROACH?
y

ENTER RUNWAY USE DIAGRAM NUMBER (1 - 51)
5

ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D)
FOR EACH PRINTED RUNWAY NUMBER
1-
0,0,50,50 all

ENTER SEPARATION "S" BETWEEN PARALLEL RUNWAYS (FEET)
1500

ENTER ARRIVAL PERCENTAGE
60

ENTER TOUCH & GO PERCENTAGE
0

ENTER EXIT DISTANCES AND RUNWAY LENGTH
(FT) FOR EACH PRINTED RUNWAY NUMBER. IDENTIFY
HIGH SPEED EXITS WITH AN "H" AFTER DISTANCE.
ENTER W AFTER RUNWAY LENGTH TO IDENTIFY WET RUNWAY.
1-
4100,4900,5500,7000,10000 w
2-
4100,4700,t

ERR: EXIT DISTANCES MUST BE POSITIVE INTEGERS ENTERED IN ASCENDING ORDER

2-
4100,4900,5500,7000,10000
```

TWO CLOSE PARALLEL, MIXED ON #1 AND #2, VFR

BATCH CAPACITY PROGRAM, VERSION 5
TO OBTAIN 60 PERCENT ARR, GAPS IN ARRIVAL STREAM MUST EXIST DURING 11
PERCENT OF THE HOUR

*** AIRFIELD HOURLY RUNWAY CAPACITY ***

TOTAL = 86.0 ARRIVAL = 51.6 DEPARTURE = 34.4

DO YOU WISH TO PERFORM ANOTHER CALCULATION?
no

FIGURE 3-7 (Cont.)

COMPUTER DIALOGUE FOR EXAMPLE 4
FIGURE 3-8

```
ex faa?

          *** AIRFIELD HOURLY CAPACITY MODEL ***
                   ON-LINE  VERSION 2

DO YOU WANT A LISTING AND IMPLEMENTATION
SCHEDULE OF FUTURE ATC SYSTEMS?
n,n,n
ATC
p
WEATHER
v
SHORT FINAL ?
y
R/W #
2
R/W MIX
1-
10,10,50,30 a
SEPARATION S
1000
ARRIVAL %
50
T & G  %
0
EXITS
1-
s



TWOPA,CLOSE, ARR ON #1,DEPT ON #2

BATCH CAPACITY PROGRAM, VERSION 5
TO OBTAIN  50 PERCENT ARR, AVAILABLE DEPARTURES CAPACITY IS REDUCED BY  16.2
 OPERATIONS PER HOUR

          ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

          TOTAL =     71.7  ARRIVAL =     35.9  DEPARTURE =     35.9


DO YOU WISH TO PERFORM ANOTHER CALCULATION?
n
```

FIGURE 3-8 (Cont.)

```
ex vfrpa

NEWRUN 0 0 0                                                                  00000010
   2  10    0
RUNWAY 1 1 0                                                                  00000030
0.150.150.500.20
RUNWAY 2 1 0                                                                  00000050
0.150.150.500.20
ARBAR2 1 2 0                                                                  00000070
48.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
63.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
63.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
72.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
ARBAR2 2 2 0                                                                  00000111
45.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
53.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
53.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
50.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
EXITPT 1 3 0                                                                  00000120
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
EXITPT 2 3 0                                                                  00000161
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
DLTAIJ 0 4 0                                                                  00000170
 1.1 1.1 1.2 1.3 3.0 1.8 1.9 1.9 3.0 1.3 1.9 1.9 5.0 5.0 3.5 2.9
APPSPD 0 5 0                                                                  00000190
 120 120 130 140
DRBAR  2 6 0                                                                  00000210
  34  34  39  39
DDSR   2 7 0                                                                  00000230
  25  30  40  50  30  40  45  50  45  45  55  60 120 120 120  90
GAMMA  0 8 0                                                                  00000250
   6   6   6   6
OTHERS 020 1                                                                  00000360
 6.018.0.004   8   0 0.0 5.03500 3.00.0   0.   0
TWO INT OR MED OR FAR PARALLEL, MIXED ON #1, ARR ON #2

BATCH CAPACITY PROGRAM, VERSION 5
TO OBTAIN    0 PERCENT ARR, ALL INTERFERING ARRIVAL STREAMS ARE ELIMINATED, AND
 GAPS IN REMAINING ARRIVAL
STREAMS MUST EXIST DURING 100 PERCENT OT THE HOUR

               ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***
```

```
TOTAL =     58.2  ARRIVAL =      0.0  DEPARTURE =     58.2


OTHERS 020 1                                                                    00000380
 6.018.0.040   8   0 0.0 5.03500 3.00.0    0.  35
TWO INT OR MED OR FAR PARALLEL, MIXED ON #1, ARR ON #2

BATCH CAPACITY PROGRAM, VERSION 5
TO OBTAIN  35 PERCENT ARR, ALL INTERFERING ARRIVAL STREAMS ARE ELIMINATED, AND
 GAPS IN REMAINING ARRIVAL
STREAMS MUST EXIST DURING  10 PERCENT OT THE HOUR

          ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

TOTAL =     89.5  ARRIVAL =     31.3  DEPARTURE =     58.2


OTHERS 020 1                                                                    00000400
 6.018.0.040   8   0 0.0 5.03500 3.00.0    0.  50
TWO INT OR MED OR FAR PARALLEL, MIXED ON #1, ARR ON #2

BATCH CAPACITY PROGRAM, VERSION 5
TO OBTAIN  50 PERCENT ARR, GAPS IN ARRIVAL STREAM MUST EXIST DURING  70
 PERCENT OF THE HOUR

          ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

TOTAL =     89.5  ARRIVAL =     44.7  DEPARTURE =     44.7


OTHERS 020 1                                                                    00000420
 6.018.0.040   8   0 0.0 5.03500 3.00.0    0.  65
TWO INT OR MED OR FAR PARALLEL, MIXED ON #1, ARR ON #2

BATCH CAPACITY PROGRAM, VERSION 5
TO OBTAIN  65 PERCENT ARR, GAPS IN ARRIVAL STREAM MUST EXIST DURING  37
 PERCENT OF THE HOUR

          ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

TOTAL =     85.4  ARRIVAL =     55.5  DEPARTURE =     29.9
```

FIGURE 3-8 (Cont.)

```
OTHERS 020 1                                                                          00000440
 6.018.0.040    8    0 0.0 5.03500 3.00.0    0. 100
TWO INT OR MED OR FAR PARALLEL, MIXED ON #1, ARR ON #2

BATCH CAPACITY PROGRAM, VERSION 5
TO OBTAIN 100 PERCENT ARR, AVAILABLE DEPARTURES CAPACITY IS REDUCED BY  12.7
 OPERATIONS PER HOUR

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =     68.0  ARRIVAL =    68.0  DEPARTURE =     0.0


OTHERS 020 1                                                                          00000460
 6.018.0.040    8    0 0.0 5.03500 3.00.0    0.9999
TWO INT OR MED OR FAR PARALLEL, MIXED ON #1, ARR ON #2

BATCH CAPACITY PROGRAM, VERSION 5
ARRIVALS 1ST PRIORITY & DEPARTURES 2ND PRIORITY WITHOUT REGARD TO PERCENTAGE
 ARRIVALS

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =     80.7  ARRIVAL =    68.0  DEPARTURE =    12.7
```

FIGURE 3-8 (Cont.)

4.1 Introduction

The Delay Simulation Model is a computer program for analyzing the movement of aircraft through an airport. One of the basic assumptions of the Batch Capacity Model described in Chapters 2, 8 and 9 is that the airfield can be divided into ruwnay, taxiway and gate components and each component analyzed separately. The Delay Simulation Model provides a method for simultaneously analyzing the total airfield including the terminal airspace associated with the runways. The model output includes a detailed hourly delay summary for each component of the airport, total travel time, and flow rates.

The Delay Simulation Model is a fast time critical event model employing Monte Carlo sampling techniques. "Fast time" means that many hours of scheduled movements can be processed through the computer in a few seconds. "Critical event" means that the internal computer clock is constantly advancing to the next event (as opposed to advancing in uniform time increments and checking to see if anything happened). "Monte Carlo sampling" means that the values of certain parameters (e.g., arrival-arrival separation, arrival runway occupancy time, gate occupancy time) are drawn at random from user defined empirical distributions. The Delay Simulation Model operates by tracing the path of each aircraft through space and time. The records of aircraft movement are processed by the model to produce desired outputs. The Delay Simulation Model is an extension of previous work by Maddison.

As noted in Chapter 1, delay to aircraft is defined as the difference between the actual time it takes an aircraft to operate on an airfield (or component) and the normal time it would take the aircraft to operate without interference from other aircraft on the airfield (or component) under the specified operating conditions. Therefore, delay as computed by the model is equal to increases in travel time attributable to congestion on the airfield and in the adjacent airspace.

Input data required by the Delay Simulation Model are summarized below. The format for input data is defined in paragraph 4.3.

- <u>Logistics</u>

  Number of runs
  Output detail desired

Start and finish times

o <u>Airfield Layout</u>

Link data (network description)
Runways
Exit taxiways
Gates
Holding areas
General aviation basing areas
Runway/taxiway intersections

o <u>Air Traffic Control</u>

Aircraft separations
Routing data (including one-way paths)

o <u>Aircraft Parameters</u>

Approach speeds
Taxiing velocities
Arrival, departure, and touch-and-go runway occupancy times
Exit taxiway utilization
Gate service times

o <u>Schedule Data</u>

Arrival time
Departure time
Gate assignment
Runway assignment

The Delay Simulation Model is modular in structure. Analysis of the total airfield or its individual components can be performed by manipulation of the model inputs. Running time for the model is dependent on the level of aircraft demand, the number of repetitions made, and the complexity of the airfield geometry.

4.1.1 Discussion of Terms

Some of the principal terms used to describe the logic of the Delay Simulation Model are:

a) <u>Link</u>. A link is a space on the airfield that can be occupied by an airplane. The length of each link is defined by the user. A link can only hold one aircraft.

b) <u>Node</u>. A node is the common point between two connecting links.

c) <u>Exit Link</u>. An exit link is the first link off the runway onto the exit taxiway.

d) <u>Taxiway Link</u>. A taxiway link is a subsection of a taxiway. Normally, taxiway links are made approximately equal to the length of the longest aircraft using the taxiway.

e) <u>Gate Link</u>. A gate link is the section of terminal apron an aircraft occupies while loading and unloading passengers.

f) <u>Basing Area Link</u>. A basing area link corresponds to a parking area for non-scheduled aircraft (e.g., general aviation and military). The entire basing area is represented by one link.

g) <u>Holding Area Link</u>. A holding area link is a location on the airfield where air carrier aircraft can be sent to wait for a gate to become available. This is sometimes called a penalty box.

h) <u>Pushback Link</u>. A pushback link is the location on the apron where an aircraft sits after initially moving off the gate while the tractor is being unhooked. Each pushback link is associated with a gate link.

i) <u>Departure End Link</u>. A departure end link is the link ajoining the threshold of a runway used by departure aircraft; i.e., it is the location a departure aircraft occupies while waiting for clearance to take off.

j) <u>Runway Crossing Link</u>. A runway crossing link is the location on a taxiway (which crosses a runway) where the decision is made to let the aircraft cross the runway. It is not, in general, the section of taxiway that physically crosses the runway.

k) <u>Route</u>. A route or path is a continuous set of links defining how aircraft travel over the airfield when going from link A to link B; e.g., exit R1 to gate F6 or link 10 to link 20.

l) <u>Directional</u>. A link may be thought of as being directional if during the complete simulation run aircraft only enter it from one end; e.g., the right end. This implies that aircraft only move in one direction on this link; e.g., right to left.

m) <u>Nondirectional</u>. A link may be thought of as being nondirectional if sometime during the simulation run aircraft enter it from both of its ends; e.g., an aircraft enters going from right to left and sometime later an aircraft enters going from left to right.

n) <u>One-way Path</u>. A one-way path is a series of nondirectional links; i.e., it is a set of links that for

certain movements have to be treated as a single link. One-way paths often occur in the taxiway between pier fingers of a terminal building but can occur at other places on the airfield. A one-way path is analogous to a one lane highway bridge. Traffic cannot move onto the one-way path unless the path is clear to move completely across. It is called a one-way path because traffic can only move on it "one-way" at a given time.

o) Pushback One-way Path. This is a one-way path which may be provided for an aircraft to enter when leaving its gate.

p) Random Number Seed. A random number seed is a number that is used to produce a random distribution of probabilities. Each random number seed produces a unique set of probabilities.

4.2 Model Logic

The Delay Simulation Model is a series of logical expressions for moving arrival aircraft from the terminal airspace through the merge point (outer marker) to the gate or basing area, and departures from the gate or basing area to the departure runway and back into the terminal airspace.

4.2.1 Overview of Aircraft Movement Logic

Arrival processing by the model starts at the entry to the common approach path. For commerical aircraft this is usually the outer marker. For each arrival aircraft, an approach speed is assigned from an empirical distribution according to the aircraft class. For each arrival pair, interarrival times, approach speeds, and wake turbulence characteristics are checked so that sufficient separation exists on the common approach path.

As each aircraft arrives over the threshold, an exit taxiway and associated runway occupancy time is assigned to the aircraft. These assignments are based on empirical distributions which take into account such factors as exit location and type, aircraft class, condition of the runway, and weather. The aircraft's routing to the gate or basing area is established in the following manner. As an air carrier aircraft exits the runway, a check is made on the availability of a gate of the correct size which belongs to the airline to which this aircraft is assigned. If an appropriate gate is be available, the aircraft's route to the gate is determined from input data based on the exit taxiway used and the gate location. In the event a gate is not available, the aircraft is routed to a holding area where further checks on gate availability are made. In the case of

general aviation or military aircraft, the aircraft's route to the basing area is assigned on the basis of the exit taxiway used and the location of the basing area.

Once an aircraft's route to the gate or basing area has been established, the aircraft is moved along its route from link-to-link on the airfield network. Each link has an assigned occupancy time. When an aircraft is ready to enter the next link, checks are made to determine whether the next link on the route is available or occupied by another aircraft. If the next link is occupied, the aircraft is not moved until the link is vacated. Thus, the travel time is increased for the particular aircraft, and delay is incurred. When the aircraft reaches its gate, a gate occupancy time is assigned from empirical distributions and is added to the gate arrival time. This information determines the earliest time at which the aircraft could leave the gate. The empirical distributions for gate occupancy time may reflect the typical bunching of the schedules of air carrier departures.

When an aircraft is ready to leave the gate, a check is made to insure that the ramp area is clear for pushback. The route to the departure runway is determined by the aircraft's basing area or gate location, the aircraft class, and the departure runways in use at that particular time.

In the case of general aviation and military aircraft, when the aircraft reaches the basing area, it is assumed to have left the system. This assumption is necessary because of the unstructured nature of general aviation and military operations on the apron.

When an aircraft reaches the threshold of the departure runway, compliance with air traffic control practices is checked and confirmed before the aircraft is cleared for takeoff. The following checks are made:

- o Has the previous arrival cleared the runway?
- o Is there sufficient separation from the next incoming arrival?
- o Is there sufficient separation from the previous departure?

If all these checks are positive, the aircraft is cleared for takeoff.

4.2.2 Aircraft Movement Logic Details

a. Arrivals. An arrival aircraft desiring to enter the common approach path must have the specified separation from aircraft on the same runway or dependent runways before

it can advance on the common approach path. If this separation is not available, the arrival is delayed until the specified separation can be achieved. This results in an alteration of the scheduled arrival time and an accumulation of delay. When an arrival comes over the runway threshold an exit is chosen by a cumulative probability distribution (CPD) based on the aircraft class and runway. The runway occupancy time is a function of the distance of the exit chosen from the runway threshold and of the aircraft class. Arrivals are assigned a gate when they exit from the runway. If a suitable gate is not available (see Gate Selection below), the aircraft is sent to a holding area. Having found a gate or holding area, a specific path is allocated to the aircraft for its movement between the exit and the gate or holding area.

b. Gate Selection and Holding Areas. Gates are defined by airline and aircraft class (size). An aircraft may use a gate of a larger aircraft size of the same airline. Gates are examined for availability in order of the preferred gate, gates of the same aircraft size, gates of the next larger aircraft size, up to the gate of the largest aircraft size. Available gates are those which are unoccupied and not currently assigned to arriving aircraft taxiing toward them. If a gate is unoccupied, the possibility of another aircraft already taxiing to that gate is checked. If no gates are available, the aircraft is sent to a holding area, and the time a suitable gate will be available is recorded.

c. Taxi-in. A taxiing aircraft moves along a path that lies between pairs of airport locations as follows:

Runway exits and gates.

Runway exits and basing areas.

Runway exits and holding areas.

Holding areas and gates.

A path is composed of a series of links. A link may belong to many paths, and a link may cross a runway. Only one aircraft is allowed to occupy a link at any one time. Aircraft can only enter a link from its ends.

The time to taxi across a link is constant. This time can be calculated from the link length and taxi velocity, or it can be input directly.

When it is time for the aircraft to advance to the next link on a path, the link is examined to determine if it is occupied. If occupied, the appropriate delay is computed. If unoccupied, the aircraft is moved to this link and its next event time is established by the time taken to travel

the link. The next link on a path may not be available for usage for several other reasons:

(1) The link is the start of a one-way path.
(2) The link is the start of a pushback one-way path. (See Pushback below.)
(3) The link crosses a runway. (See 4.2.3.)

If the link to be entered is the start of a one-way path, the model checks to see that all of the links on the one-way path are unoccupied before allowing the aircraft to move. If one of the links of the one-way path is occupied, the model will determine the direction in which the aircraft occupying the one-way path is traveling. If aircraft x, occupying one of the links on a one-way path, is going in the same direction as aircraft y wishing to enter the one-way path, the model will allow aircraft y to enter the one-way path. If aircraft x is going in the opposite direction of aircraft y, aircraft y is delayed until the one-way path is unoccupied.

If a physical taxiway is wide enough to accommodate aircraft going in opposite directions simultaneously, the taxiway should be considered as two independent taxiways and divided into directional and non-directional links as appropriate.

d. Gate Operations. The gate service time for each aircraft is computed from a normal distribution. Each aircraft class has its own distribution function specified by a mean and standard deviation. When an aircraft reaches its gate, a gate service time is added to the actual arrival time to determine the earliest possible departure time. The actual departure time is the later of the earliest possible departure time and the scheduled departure time.

e. Pushback. The pushback operation is the first event on leaving the gate. Before a pushback is started, a check is made to determine if a pushback one-way path has been defined for this gate. If a pushback one-way path has been defined for this gate, the model checks to see that none of the links between the gate and the start of the pushback one-way path is occupied by an incoming aircraft. If it is, the pushback is delayed until the arrival aircraft has reached its gate or has passed the pushback link. The pushback one-way path is then checked again for occupancy by an arriving aircraft.

A one-way path used for pushback operations can have several entry points (as opposed to a single link which can have only two entry points). If a pushback one-way path is composed of N links, it can have N+1 entry points; i.e., it can be entered from one end and at the beginning of each link.

f. Taxi-out. A taxiing aircraft moves along a path between a gate or basing area and a departure runway. The

logic for moving aircraft from link to link is identical to that described in 4.2.2c above.

g. Takeoff. When a departure reaches the departure end link the runway traffic is checked to determine whether the departure can enter the runway and take off in adherence to air traffic control procedures specified. If the departure cannot fulfill all the air traffic control procedures, it is delayed till favorable conditions exist.

To prevent excessive departure queues and delay, the model checks to see if the takeoff queue is larger than a specified length, say five aircraft. If these conditions exist, the model will insert a time gap in the arrival stream for that runway and any dependent runways. The time gap is inserted before the next plane due to arrive. (The order of arrival for that runway in the schedule is not changed.)

h. Touch-and-Go. A touch-and-go operation only affects the common approach path and the runway. The touch-and-go runway occupancy time is given by a normal distribution for each aircraft class.

i. General Aviation (G/A). Each general aviation basing area is considered to have an infinite capacity. General aviation arrivals taxi to the basing area and are then terminated. General aviation departures must be included separately in the schedule.

4.2.3 ATC Separation Logic

The air traffic control separation logic applies only to aircraft operating on or to runways, and controls:

Runway Occupancy
Arrival-Arrival Separation
Departure-Departure Separation
Departure-Arrival Separation
Arrival-Departure Separation

Separation standards are input for each lead and trail aircraft class pair (e.g., a C class aircraft followed by a B class aircraft) for a single runway and any dependent runways. Separation standards are defined by four 2 x 16 matrices of mean and standard deviation values.

Arrivals have first priority for use of the runways. Before an arrival is permitted to land, its runway is checked to see that a previous arrival is not occupying the runway, and that the specified separation exists from the previous arrival on that runway. The model also checks to see that the specified separation exits on any dependent (i.e., parallel, intersecting, etc.) runway.

For single and dependent runways, priority between arrival operations for use of the common approach path is determined by their event time (minute and hundreth of a minute). The event time is the sum of the input schedule arrival time and delay imposed from other aircraft.

The Delay Simulation Model will permit simultaneous arrivals on close spaced parallel runways unless a small or large aircraft trails a heavy aircraft. In this case, the small or large aircraft is sequenced behind the heavy aircraft with a separation assigned by the model inputs that reflect wake turbulence separation.

Departures have second priority for use of the runways. Before a departure is permitted to occupy the runway and take off, the following checks are made:

a. The runway is not occupied by an arrival or previous departure.

b. The specified separation exists between the departure and the next arrival on the takeoff or dependent runway.

c. The specified separation exists between the departure and the previous departure on the takeoff or dependent runway.

For dependent runways, priority between departure operations for use of the runways is determined by the time they arrive at the departure end link and by conformance with the specified air traffic control separations. For example, if a departure on one runway cannot be cleared because of air traffic control separations, the model checks to see if a departure on the dependent runway could be cleared.

Runway crossings have the lowest priority for use of the runway. A runway crossing can occur if:

a. The runway is not occupied by an arrival or departure.

b. No departures are waiting to use the runway.

c. The aircraft can cross the runway before the arrival comes over the threshold.

The model will permit multiple aircraft to cross the runway between arrival or departure operations. If a runway is operating at capacity, it will be very difficult to cross the runway. The arrival or departure must be clear of the runway before the taxiing aircraft can cross the runway.

4.2.4 Aircraft Descriptions

Four classes (or types) of aircraft can be identified with the Delay Simulation Model. A recommended set is:

Type Number	Class Letter	Description
1	D	Heavy jet; B747, DC10, L1011, DC8-61, B707-3
2	C	Large aircraft; B727, B737, DC-9, CV58
3	B	Small twin-engine aircraft; BE99, LR25
4	A	Small single-engine aircraft; C150, BE23

Aircraft are identified to the model by their type number.

In general, any definition of aircraft classes is possible subject to the constraint that:

type 1 aircraft are larger than type 2,
type 2 aircraft are larger than type 3, and
type 3 aircraft are larger than type 4,

This condition is necessary for the gate logic where it is assumed that an aircraft can use a gate for its type number or of a lower type number.

Four flight types are available for use with the Delay Simulation Model. They are:

Flight Type Number	Description
1	Originating
2	Terminating
3	This value unassigned
4	Turnaround
5	Touch-and-Go

While an aircraft is being moved within the model, it is assigned a status as listed below.

Aircraft State Number	Description
0	Not Arrived
1	Queued
2	On Way to Gate
3	In Gate
4	On Way to Takeoff
5	Taken Off
6	In Pushback from Gate to Takeoff
7	In Holding Area
8	In Pushback from Holding Area to Gate

4.2.5 Schedule of Operations (i.e., Aircraft Demand)

The schedule data consists of:

airline code
flight number
aircraft type
flight type
scheduled arrival time at threshold
scheduled departure time from gate
preferred gate
arrival and departure runways

The scheduled arrival times used by the model are arrival times at the threshold. The input arrival time should take into account the desired arrival time as reflected in the Offical Airline Guide (OAG) and delays due to the originating airport and enroute airspace. This can be accomplished by manually applying a "lateness distribution" to the desired arrival times.

The scheduled arrival times do not include delays due to airfield congestion. The time at which an arrival is observed to cross the threshold in actual operation includes delay due to airfield congestion and therefore differs from scheduled arrival time.

The runway use strategy is determined by the designation of arrival and departure runways. For multiple runway geometries, the user should make an effort to decide which

runway an operation would use based on the origin or destination of the aircraft.

General aviation aircraft do not follow fixed arrival or departure schedules. One approach in determining when to schedule general aviation demand during an hour is to randomly distribute the general aviation demand over the hour in accordance with a standard probability function.

At the beginning of each run, the model assumes that no aircraft are on the airfield. Traffic begins to build up on the airfield according to the aircraft schedule. It is recommended that at least the first hour of a run be used to impose an initial load on the airfield system.

4.2.6 Airport Geometry

The geometry of the airport is entered into the model in the form of a series of numbers from a "link-node diagram." Figure 4-1a illustrates an airfield geometry containing two parallel runways. Figure 4-1b is a link-node diagram developed from this geometry. The technique is to break the taxiway network into a series of numbered links. Link length should not be shorter than the length of the largest aircraft using the taxiway. The link-node diagram assists in defining paths from runway to gates or holding areas, and from gates to runways.

The following relates to the development of a link-node diagram:

a. The model treats an active runway as a single link. Runways that are only used as taxiways can be divided into links.

b. A runway can only have one departure end link.

c. Runway exits cannot be defined as departure end links. (If they are, the arrival will land, exit and immediately take off.)

d. Even if identifiable holding areas (or penalty boxes) do not physically exist on the airport, some provision should be made for holding areas on the airfield in the link-node diagram. This would account for the ability to hold aircraft on taxiways.

e. Two basic kinds of taxiway intersections can be modeled; i.e., Y and link-node. A Y intersection is one at which all the links coming into the intersection are directional. This is illustrated in Figure 4-2(a). A link-node intersection allows opposing traffic to approach the intersection and continuing in a common direction. A link-

node intersection is one where the intersection node must be treated as a link. This is illustrated in Figure 4-2(b).

f. The link after a runway crossing link can be defined to give the desired separation between hold line and runway edge, and clearance across the runway.

The link-node diagram can be used to incorporate some operational characteristics. The following are some typical examples:

a. <u>Bi-directional Operations</u>. By defining a single runway as two dependent runways in the link-node diagram and defining the appropriate departure-arrival and arrival-departure separations, bi-directional operations on a single runway can be modeled.

b. <u>Intersection Takeoffs</u>. By defining a single runway as two dependent runways (e.g., Runway 1 and Runway 2) in the link-node diagram, assigning departure end links to each runway, intersection takeoffs can be modeled. This requires that the following air traffic control separation matricies be defined:

Arrival-Arrival
- Runway 1 on Runway 1
- Runway 1 on Runway 2
- Runway 2 on Runway 1

Departure-Departure
- Runway 1 on Runway 1
- Runway 1 on Runway 2
- Runway 2 on Runway 1

Departure-Arrival
- Runway 1 on Runway 1
- Runway 1 on Runway 2
- Runway 2 on Runway 1

Arrival-Departure
- Runway 1 on Runway 2
- Runway 2 on Runway 1

c. <u>Taxiway Intersection Clearance Strategy</u>. Normally, the model gives the first aircraft to a taxiway intersection priority to cross through the intersection. However, by judiciously defining link length and by using one-way paths, priority can be given to operations on one taxiway over operations on another taxiway.

d. <u>Runway Crossing</u>. The model requires that a crossing operation occur before the next arrival comes over the threshold. It does not specify any separation between a crossing aircraft and incoming arrivals. For crossings near

the threshold, a separation between the crossing aircraft and the arrival can be achieved, in effect, by specifying a longer length for the link after the runway crossing link than is actually present. It would also be necessary to specify a shorter distance for the next taxiway link in the path to compensate for the time distortion.

4.2.7 Delay Computation

The elements of delay produced by this program are defined below. Total delay is the sum of these quantities.

Arrival runway delay - the difference between actual time of landing and the time of landing computed from the schedule.

Departure runway delay - the time difference between the start of takeoff roll and the time the aircraft reached the takeoff runway or the departure queue.

Arrival gate delay - delay caused by gates not being available.

Departure gate delay - delay caused by the pushback link being occupied.

Taxi-in delay - delay (except runway crossings) incurred when attempting to move to the next link on a path leading to a gate or holding area.

Taxi-out delay - delay (except runway crossings) incurred when attempting to move to the next link on a path leading to a takeoff runway but excluding departure queue delay.

Taxi-in runway crossing delay - delay encountered by an aircraft on the way to a gate or holding area while attempting to cross a runway.

Taxi-out runway crossing delay - delay encountered by an aircraft attempting to cross a runway on the way to a takeoff runway.

An attempted movement may be delayed more than once. Delays are ignored if they are less than .005 minutes.

Because certain model parameters are stochastic in nature (time variant and random), the result of applying one random number seed is equivalent to the operation of an airfield for only one time interval (e.g., a few hours or 1 day). In order to arrive at average or typical values for day-to-day variations of airfield operation, it is necessary to employ several different random number seeds for each run of the

model. The output of the model is automatically averaged across all random number seeds to represent the average operational characteristics (flow rates, delays, etc.) of the airfield. A preliminary analysis was made of the number of random number seeds required to attain the stochastic convergence necessary to obtain outputs representative of typical airfield operations. This analysis showed that at least five runs are necessary to attain reasonable convergence for each fixed set of input parameter values. Ten runs are recommended.

4.2.8 Flow Rate Computation

Flow rate is measured by the Delay Simulation Model as the number of operations that pass a point on the airfield within an hour. Since several random number seeds may be used in a given run, the output flow rate is the average flow rate over all random number seeds.

The Delay Simulation Model updates the flow rate counting mechanism when an aircraft passes one of the following points on the airfield.

Type of Flow Rate	Point Where Measured
Arrival	Threshold
Departure	Off Runway
Touch-and-go	Threshold
On-gate	Gate Arrival
Off-gate	On Completion of Pushback
Taxi-in	Runway Exit
Taxi-out	Off-gate

The grand total flow rate on the runway(s) is computed by:

grand total flow = arrival flow rate + departure flow rate + (2 x touch-and-go flow rate)

4.2.9 Travel Time Computation

Travel time is computed as follows:

a. Arrivals - time to go from runway threshold to gate or basing area. The average arrival travel time per hour

includes only those arrivals which reach their gate or basing area within the given hour.

b. Departures - time to go from gate or basing area to the departure runway (and cleared to takeoff). The average travel time per hour contains those departures which takeoff within the given hour.

It should be noted that when comparing delays for several runway use configurations that the differences in travel time between runway use configurations are also forms of delay. Differences in travel time represent the additional taxi time required by one runway use configuration as opposed to some other runway use configuration.

4.2.10 Premature Termination of Run

A model run will be prematurely terminated if one of the following conditions occurs:

a. If all gates and holding areas are full.

b. If no path exists from:

exit to gate,
exit to holding area,
holding area to gate, or
gate to departure runway.

c. If an airline name used in the schedule data is not defined on AIRLINE NAMES.

d. If the same plane is delayed at a link 50 times in a row without the event time being advanced. In this case no model statistics will be output.

e. If more than 599 links are entered.

f. If more than 1400 paths are entered.

4.2.11 Parameter Distributions

Values for the following parameters are considered to be normally distributed between the limits of two standard deviations from the mean:

Arrival-Arrival Separation
Arrival-Departure Separation
Departure-Departure Separation
Departure-Arrival Separation
Gate Service Time
Departure Runway Occupancy Time

Approach Speed
Touch-and-Go Runway Occupancy Time

Exit taxiways are selected according to an input empirical distribution of exit utilization percent by aircraft class. This distribution defines the percent of each aircraft class that will use each exit.

Values for the following parameters are considered to be equal to the mean value:

Length of Common Approach Path
Arrival Runway Occupancy Time Per Exit
Taxiway Velocity

4.3 Input Format

The following general instructions apply to preparing inputs to the Delay Simulation Model:

1. Data entry requires two or more cards depending on data type; i.e.,

   Header Card; e.g., TITLE
   Data Card(s); e.g., LAX DELAY ANALYSIS.

2. The header cards have to be exactly as given on the coding form.

3. There is no fixed sequence for groups of header/data cards except that:

   RWY NO. OF must precede RWY NAMES and RWY END LINKS

   AIRLINE NAMES must precede AIRLINE GATES

   A/C SCHEDULE must precede A/C SERVICE TIMES, A/C APPROACH SPEEDS and AIRLINE NAMES

4. Multiple runs can be made with one stack of cards. Place replacement header/data cards after the COMPUTE card for the first run.

5. Normally, the user will specify FA (or FALSE) for print options 1, 2 and 3. Print option 4 has been set as TRUE in the model code. It is recommended that print option 5 be entered as FA (or FALSE). If print option 5 is TR, the model will stop if two aircraft meet nose-to-nose on a taxiway. If print option 5 is FA, the model will print a warning message if this situation occurs and allow the run to complete. Print option 6 should be

entered as FA unless detailed queue information is desired.

The normal model outputs (delay, travel time and flow rate statistics) are automatically printed for every run.

6. The model will first try to assign an aircraft to its preferred gate. If that gate is occupied, it will try to assign the aircraft to a gate of the appropriate airline that can accommodate the aircraft size. Since class C aircraft can use gates for C or D type aircraft, it is advisable to enter the gate numbers on the AIRLINE GATES card in the order of those used only by large aircraft; i.e., those used by class C and class D aircraft, followed by those used (only) by class D aircraft.

7. The model as programmed in Version 2 accommodates up to the following array sizes. The array sizes can easily be increased in the program DIMENSION statements if more flexibility is required.

   a) four active runways

   b) four aircraft types

   c) 20 airlines

   d) Simulated run times of 24 hours

   e) 599 links

   f) 1400 paths

   g) 28,000 items in path descriptions

   h) 20 one-way paths

   i) 25 links in any one-way path

   j) 10 general aviation gate areas

   k) 20 gates per airline

   l) 10 holding areas

   m) 10 runway crossing links

   n) 200 runway exits

   o) 10 random number seeds per run

8. Routing Path Data:

a) Routes are required from:

exits to gates
exits to basing areas
exits to holding areas
holding areas to gates
gates to departure end links
basing areas to departure end links

b) Taxiway routes are defined as a series of connecting links. Links can be of any length. Usually, the length of a link is determined such that: (1) it can hold the longest aircraft expected to use the route, and (2) the sum of the link lengths equals the length of the taxiway section.

c) A runway is not divided into links.

d) A runway can only have one departure end link. Departure end links are associated with runways by the sequence in which they are entered on the RUNWAY END LINKS card; i.e., the end link in cc 1-8 is assigned to Runway 1, cc 9-16 is assigned to Runway 2, etc.

e) A departure end link cannot also be an exit link.

f) All holding area links should be located in a common area.

g) Do not enter two gate links on a route; e.g., if links 1 and 6 are defined as gates, do not enter a route like 100 99 98 20 19 6 18 17 1.

h) A runway crossing link is the link just before the runway to be crossed. The link that crosses the runway should be long enough to insure adequate clearance before and after the aircraft crosses the runway.

i) Link numbers can range between 1 and 9999.

9. One-way Path Data:

a) A link can be part of many one-way paths.

b) A series of links in a path can be determined to be non-directional if they are used in another path in reverse order;

e.g., if Path 10 consisted of links 1 2 <u>20</u> <u>21</u> <u>22</u> 203 and path 57 consisted of links 206 25 24 23 <u>22</u> <u>21</u> <u>20</u> 99 100, links 20 21 22 are non-directional. Further analysis may be necessary to determine the complete set of non-directional link#s on this taxiway.

c) If a series of links are found to be non-directional (see above), two one-way paths are required unless the series of links is the taxiway feeding a series of gates. For example, if links 20 21 22 23 24 and 25 are found to be a continuous set of non-directional links, the required one-way paths are:

20 21 22 23 24 25 and
25 24 23 22 21 20

If a series of non-directional links is the taxiway feeding a series of gates, a one-way path is required from the entrance to the end of the one-way path. This one-way path will serve as the pushback one-way path for each gate.

d) Aircraft may not enter or exit the middle of a one-way path except to enter or push-back from a gate. If a one-way path serves a series of gates, aircraft can only enter the one-way path at one end. Examples of one-way path geometry and input data are shown in Figure 4-4.

e) A series of links that form a one-way path cannot be input as two or more one-way paths to avoid the 25 link limit on the number of links composing a one-way path.

10. Schedule Data:

a) The scheduled arrival times must be in a merged sequence from earliest to latest; i.e.,

ARRIVAL	DEPARTURE
17:05	18:10
17:08	0:0
17:15	18:30
17:15	17:55
17:20	17:53

b) All aircraft which originate at a gate; i.e., flight type 1, must be at the beginning of the schedule.

c) Arrival and departure times are required for through flights; i.e., those which arrive, occupy the gate and depart.

d) Enter the basing area number as the preferred gate of a general aviation arrival aircraft. General aviation arrivals have no departure time. General aviation arrivals must be entered as flight type 2.

e) All general aviation departures must be entered as flight type 1. General aviation departures have no arrival time.

f) Touch-and-go operations require an arrival time but no departure time. Enter 0 for preferred gate.

11. Aircraft Separation:

a) A set of aircraft separation matrices are required for a single runway and for all dependent runway pairs.

b) Each set of aircraft separation matrices may consist of individual matrices for:

Arrival-Arrival Separation in nautical miles

Departure-Departure Separation in minutes

Departure-Arrival Separation in nautical miles

Arrival-Departure Separation in minutes

c) Each matrix contains separation values (i.e., mean and standard deviation) for given lead and trail aircraft type pairs; i.e., up to 16 pairs of separation values.

d) Only those elements in a separation matrix that are required by the schedule data need be input. For example, if no type 1 aircraft were in the schedule, no separations involving type 1 aircraft need be entered.

e) Only those separation matrices required by the schedule data need be input. For example, if all arrival operations are on Runway 1 and all departure operations on Runway 2 and Runways 1 and 2 are dependent, departure-arrival separation values for Runway 2 on Runway 1 are required but arrival-arrival, departure-departure and arrival-departure separations for

Runway 1 on Runway 2 and Runway 2 on Runway 1 as well as the departure-arrival separation for Runway 1 on Runway 2 are not required. The full set of separation matrices for a single runway would be required.

f) Separation matrices for a single runway should be entered as Runway 1 on Runway 1. This set of matrices is used for all single runways. Therefore, separation matrices for Runway 2 on Runway 2, Runway 3 on Runway 3, etc., are not required.

g) The input arrival-arrival separation by aircraft pair SEPAR(I,J) can be determined from observed separations over threshold as follows:

IF VI ≤ VJ:
SEPAR(I,J) = OTS (I,J) x VJ/60

IF VI > VJ:
SEPAR(I,J) = OTS (I,J) - (60 x GJ x FV)

where
VI = velocity of lead arrival in nautical miles
VJ = velocity of trailing arrival in nautical miles
OTS (I,J) = observed time separation over threshold between aircrafts I and J in minutes
GJ = length of common approach path for the trailing arrival.

$$FV = \frac{1}{VI} - \frac{1}{VJ}$$

The input arrival-arrival separation for the Runway Capacity Model is related to the input arrival-arrival separation for the Delay Simulation Model by the equation:

SEPAR(I,J) = DLTA(I,J) + SIGAA(I,J) x F(PV)

where
SIGAA(I,J) = standard deviation of arrival-arrival separation for aircraft I and J in n.mi.
F(PV) = number of standard deviations to be protected

12. Random number seeds should be at least a four digit number; e.g., 3001.

13. A pre-processor is described in Appendix E for preparing routing data inputs. Use of this pre-processor will substantially reduce the effort required to prepare routing inputs.

14. Sample job control cards are shown in Figure 4-5. NOTE: The schedule data must be read from a previously created file NU2 on unit 8. However, the header card AIRCRAFT SCHEDULE must go with the bulk data.

15. Data which is to be entered in decimal format can be placed any where in the indicated card columns. Data which is entered in integer format must be right justified. Data which is entered in alphanumeric format must be left justified.

The following is a description of how to prepare inputs for the Delay Simulation Model Version 2. A sample input form illustrating this information is shown in Figure 4-6.

(LJ) = Left Justified
(RJ) = Right Justified
cc = Card Column

DATA TYPE		DESCRIPTION
1 Title	cc 1-5	"TITLE"
	cc 1-80	Any Heading Data
2 Random Number Seeds	cc 1-19	"RANDOM NUMBER SEEDS" (LJ)
	cc 1-8	Number of random number seeds (RJ)
	cc 1-80	Up to 10 random number seeds, 1 every 8 cc (integer) (RJ)
3 Start & Finish Times	cc 1-19	"TIMES(START,FINISH)"
	cc 4-5	Starting hour (integer) (RJ)
	cc 7-8	Starting minute (integer) (RJ)
	cc 12-13	Finishing hour (integer) (RJ)

		cc 15-16	Finishing minute (integer) (RJ)
4	Print Options	cc 1-13	"PRINT OPTIONS"
		cc 1&2	("TR" or "FA") Option 1 Detail Aircraft Movement
		cc 9&10	("TR" or "FA") Option 2 Debugging Statements
		cc 17&18	("TR" or "FA") Option 3 Hourly Data for Each Seed
		cc 25&26	("TR" or "FA") Option 4 Warning Messages
		cc 33&34	("TR" or "FA") Option 5 aircraft nose to nose
		cc 41&42	("TR" or "FA") Option 6 queuing statistics
5	Number of Runways	cc 1-11	"RWYS NO. OF"
		cc 1-8	Number of runways, (integer) (RJ)
6	Runway Names	cc 1-9	"RWY NAMES"
		cc 1-80	Runway names, 1 every 8 cc (LJ)
7	Departure Runway End Link Numbers	cc 1-13	"RWY END LINKS"
		cc 1-32	End link numbers (integer), 1 every 8 cc (RJ) (up to 4)
8	Runway Crossing Links	cc 1-14	"RWY XING LINKS"
		cc 1-80	Any header data
		cc 1-8	Runway number (integer) (RJ)
		cc 9-16	Crossing link number

			(integer) (RJ) Each pair of runway-crossing link numbers is on a separate card; data cards are read until a negative runway number is encountered.
9	Inter-arrival Gap	cc 1-20	"RWY INTERARRIVAL GAP"
		cc 14-16	Departure queue length (number of aircraft) (integer) (RJ)
		cc 29-32	Inter-arrival gap in minutes (decimal)
10	Runway Occupany Time On Departure (in seconds)	cc 1-24	"RWY DEP. OCCUPANCY TIMES"
		cc 6-8	Class (integer) (RJ)
		cc 17-24	Mean (decimal)
		cc 33-40	Standard deviation (decimal) (Data cards are read repeatedly until a negative class value is encountered.)
11	Runway Occupancy Time for Touch-and-Go (in seconds)	cc 1-24	"RWY T/GO OCCUPANCY TIMES"
		cc 1-40	Same pattern as "Runway Occupancy Time on Departure" above.
12	Lengths of Common Approach Paths	cc 1-36	"RWY LENGTHS OF COMMON APPROACH PATHS" (Data cards are read repeatedly until neg. runway value encountered.
		cc 7-8	Runway number (integer) (RJ)

	cc 15-16	Class number (integer) (RJ)
	cc 17-24	Length (decimal) nautical miles
13 Probability Distributions for Exit Selection	cc 1-18	"RWY EXIT SELECTION" (Data cards are read until neg. class value encountered.)
	cc 6-8	Class (integer) (RJ)
	cc 14-16	Runway number, (integer) (RJ)
	cc 22-24	Number of pairs of exit, probability values (integer) (RJ). Sum of input probabilities per runway must sum to 1.0.
	cc 1-80	Pairs of Exit Number (integer), (RJ); Probability (decimal)
14 Runway Exit Distances (on arrival)	cc 1-18	"RWY EXIT DISTANCES"
	cc 1-8	Number of exit pairs (integer) (RJ)
	cc 1-80	(Exit #, Distance in feet) (integer, decimal) 1 every 8 cc (RJ) (Data cards are read repeatedly, as needed.)
15 Runway Arrival Occupancy Times	cc 1-27	"RWY ARRIVAL OCCUPANCY TIMES" (Data cards are read repeatedly until negative class value encountered.)
	cc 6-8	Class (integer) (RJ)
	cc 14-16	Number of pairs of

		(distance, time) (integer) (RJ)
	cc 1-80	Pairs of (distance in feet, time in seconds) 1 every 8 cc (decimal) (LJ)
16 Holding Areas	cc 1-13	"HOLDING AREAS"
	cc 1-8	Number of holding areas (integer) (RJ)
	cc 1-80	Holding area numbers (integer), 1 every 8 cc (RJ)
17 Standard Taxi Speeds	cc 1-36	"TAXIWAY SPEEDS (SIX STANDARD SPEEDS)"
	cc 1-48	Standard link taxi speeds (decimal), miles per hour, 1 every 8 cc
18 Link Data	cc 1-13	"TAXIWAY LINKS" (Data cards are read until negative speed code encountered.)
	cc 1-80	Any header data
	cc 1-8	Link number (integer) (RJ)
	cc 9-16	If this link is not a gate, leave blank. If this link is a gate, enter the class number of the largest aircraft. (integer) (RJ)
	cc 17-24	If using a standard taxi speed, enter the length of the link in feet; if not using a standard taxi speed, enter the time to travel in minutes (decimal) (feet or minutes).

		For gate links, enter the pushback time in minutes (decimal).
	cc 33-40	Number in table of standard taxi speeds. If using a non-standard taxi speed, enter "7" (integer) (RJ)
	cc 49-56	One-way path number for gate links, holding area links or general aviation basing area links that have pushback operations onto a one-way path. (integer) (RJ)
19 Route Descriptions	cc 1-14	"TAXIWAY ROUTES" (Data cards are read until negative link count encountered.)
	cc 1-8	Number of links in the route (integer) (RJ)
	cc 1-80	Link numbers, 1 every 8 cc (integer) (RJ) Continue on next card, if required.
20 One-way Paths	cc 1-15	"TAXIWAY ONE-WAY"
	cc 1-8	Number of links (integer) (RJ) (Data cards are read until a negative number of links is encountered.)
	cc 1-80	Link numbers, 1 every 8 cc (integer) (RJ)
21 Airline Code Names	cc 1-13	"AIRLINE NAMES"
	cc 1-8	Airline count (integer) (RJ) (up to 10)
	cc 1-80	Airline code names, 1 every 8 cc (alphanumeric) (LJ)

22 Airline Gate Assignments	cc 1-13	"AIRLINE GATES" (Data cards are read until negative gate count encountered.)
	cc 1-4	Airline code (alphanumberic) (LJ)
	cc 9-16	Gate count (integer) (RJ)
	cc 1-80	Gate number, 1 every 8 cc (RJ) (integer)
23 Gate Service Times	cc 1-17	"A/C SERVICE TIMES" (Data cards are read repeatedly until neg. class value encountered.)
	cc 6-8	CLASS (integer) (RJ)
	cc 17-24	MEAN (decimal), minutes
	cc 33-40	Standard deviation of service time on gate (decimal)
24 Approach Speeds	cc 1-19	"A/C APPROACH SPEEDS" (Data cards are read repeatedly until neg. class value encountered.)
	cc 6-8	Class (integer) (RJ)
	cc 17-24	Mean speed in knots (decimal)
	cc 33-40	Standard deviation of speed (decimal)
25 Aircraft Separations	cc 1-15	"A/C SEPARATIONS"
	cc 1-80	Any header data
	cc 1-80	Any header data
	(Leading A/C Operation)	
	cc 8	Operation (A or D):

		i.e., (arrival or departure)
	cc 9-16	Class number (integer) (RJ)
	cc 17-24	Runway number (integer) (RJ)
	(Following A/C Operations)	
	cc 32	Operation (A or D)
	cc 33-40	Class (integer) (RJ)
	cc 41-48	Runway number (integer) (RJ)
	cc 49-56	Mean separation, nautical miles, except departure followed by departure and arrival followed by departure which is in minutes (decimal)
	cc 57-64	Standard deviation of separation (decimal) (Data cards are read repeatedly until neg. class number encountered.)
26 A/C Schedule	cc 1-12	"A/C SCHEDULE". This header card goes with the bulk data and causes the aircraft schedule data to be read from the file NU2.

The following is the format of the aircraft schedule data to be created on file NU2:

	cc 1-80	Any heading (Data cards are read until negative gate number encountered.)
	cc 1-4	Airline name (alphanumeric) (LJ)
	cc 9-16	Preferred gate (integer) (RJ)

cc 17-24 Flight type (integer) (RJ)

cc 25-32 Aircraft class (integer) (RJ)

cc 36&37 Arrival time at the threshold, hours (integer) (RJ)

cc 39&40 Arrival time, minutes (integer) (RJ)

cc 44&45 Departure time from the gate, hours (integer) (RJ)

cc 47&48 Departure time, minutes (integer) (RJ)

cc 49-56 Landing runway number (integer) (RJ)

cc 57-64 Departure runway number (integer) (RJ)

27 General Aviation

cc 1-16 "G/A HOLDING AREA"

cc 1-8 Number of general aviation holding areas (integer) (RJ)

cc 1-80 General aviation holding area link numbers, one every 8 card columns (integer) (RJ)

28 Processing Options

Several processing options are available:

cc 1-16 "PRINT INPUT ONLY"

This will cause a printout of all the input data in the memory at that time. This capability provides the option of data checking before running the model.

cc 1-7 "COMPUTE"

This will cause a computation or model run using the most recently input set of data. This card may be

followed by any other data, which would be followed by another "COMPUTE" card. This card provides the facilities of batching different sets of data in one program run. For example, a user could input initial data, compute, input different gate service lines, compute, input different separations and different runways, compute, etc., all in one computer run. Each "COMPUTE" card will result in all data being printed and the model run against that data.

It is recommended that initially only one random number seed be used till all coding errors have been removed from the input cards. This will minimize costs associated with debugging the inputs.

29 Completion of Run

The last input card is:

cc 1-4 "STOP"

4.4 Output

The normal output of the Delay Simulation Model is the average delays, flow rates and travel times for the number of random number seeds specified. The normal output includes:

Listing of input data

Average delay per all operations
for each hour of the run
by location on the airport

- o Runway
- o Taxiway
- o Gate
- o Runway/Taxiway Crossing Points

by arrival & departure for total airfield

Flow rates (and aircraft mix)
for each hour of the run
by location on the airport

- o Runway
- o Taxiway
- o Gate

by arrival, departure and touch-and-go

Total Travel Time
for each hour of the run
by runway
by arrival and departure

Average delay per link
by taxi-in
by taxi-out

NOTE: The statistics for the first hour represent a period when the airfield goes from an unloaded to a loaded condition. The statistics for this hour should be disregarded.

The input data is listed in a predetermined sequence; i.e., it may not be listed in the order the user entered. The header cards shown in the output are different than those required by the input. The format of the output numbers is different than that required by the input. The output identifies the separations for a single runway as: runway 0 on runway 0. The output of exit selection is the cumulative probability for aircraft to use an exit instead of the input probability.

Delay is counted as each increment occurs. For example, if an aircraft starts to taxi to a gate at 8:55 and arrives at the gate at 9:05, any delays that occur before 9:00 will be part of the 8:00 to 9:00 taxi-in delays, and the delays that occur after 9:00 will be part of the 9:00 to 10:00 taxi-in delays.

Delay per link is only shown for those links experiencing delays. Delay due to departure aircraft holding short of the runway for takeoff clearance is counted as departure runway delay.

Optional output can provide the above statistics for each random number seed. This output is displayed in a format that uses model variable names. Figure 4.3 defines the variable names used in this optional output.

The Delay Simulation Model can document the step-by-step movement of each aircraft through the airport. Any statistic available from the model can be obtained by analysis of the detail movement output. The format of the detail movement output is given in Figure 4-7.

The Delay Simulation Model will output warning messages if any of the following occur:

a) If delay on a link is less than or equal to 0 for a particular aircraft.

b) If all gates for a particular aircraft size are full.

c) If two aircraft come nose to nose on adjacent links.

d) If an individual aircraft delay on a link is greater than 6 minutes.

e) If an exit number does not have an exit distance.

f) If the probabilities input for RWY EXIT SELECTION do not sum to 1.0.

g) If the holding area is full.

The Delay Simulation Model can output the departure queue data. The model output gives:

Runway Number
Departure Queue
Time

From this information the average queue during any period of time can be determined. This information is generated by exercising Print Option 6.

If the model discovers that:

a. An incorrect header has been used; e.g., AL NAME instead of AIRLINE NAMES.

b. Too many data cards have been entered for a data type.

c. Too few data cards have been entered for a data type.

d. A minus sign has not been entered where required.

The model will print:

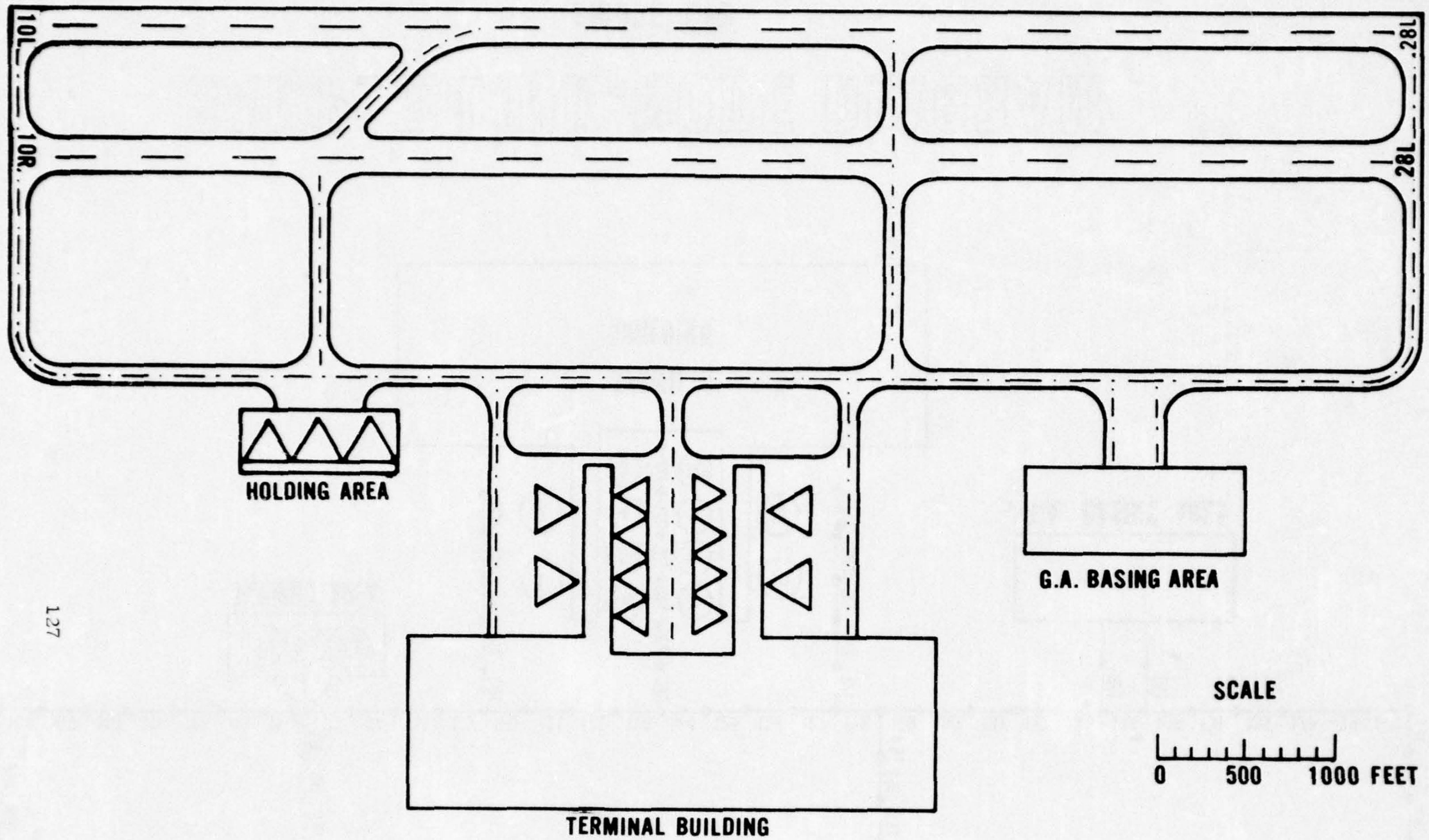
INPUT ENTRY CANNOT BE FOUND IN BRHEAD TABLE

This indicates that some data error has been made following the last printed header label.

NOTE: The BRHEAD table contains a list of all header cards.

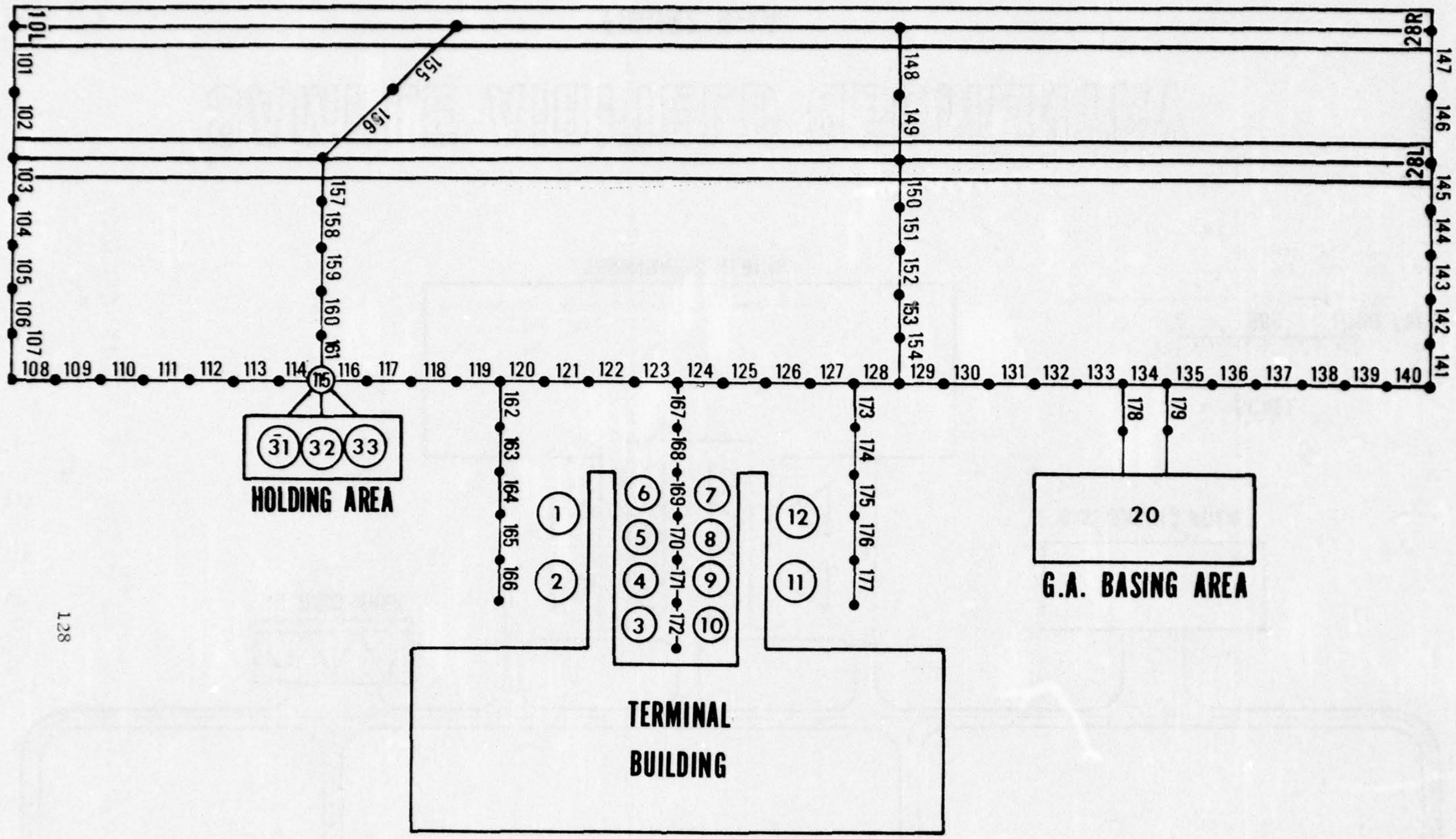
4.5 Examples

The examples for this model are contained in Book 2 of this report.



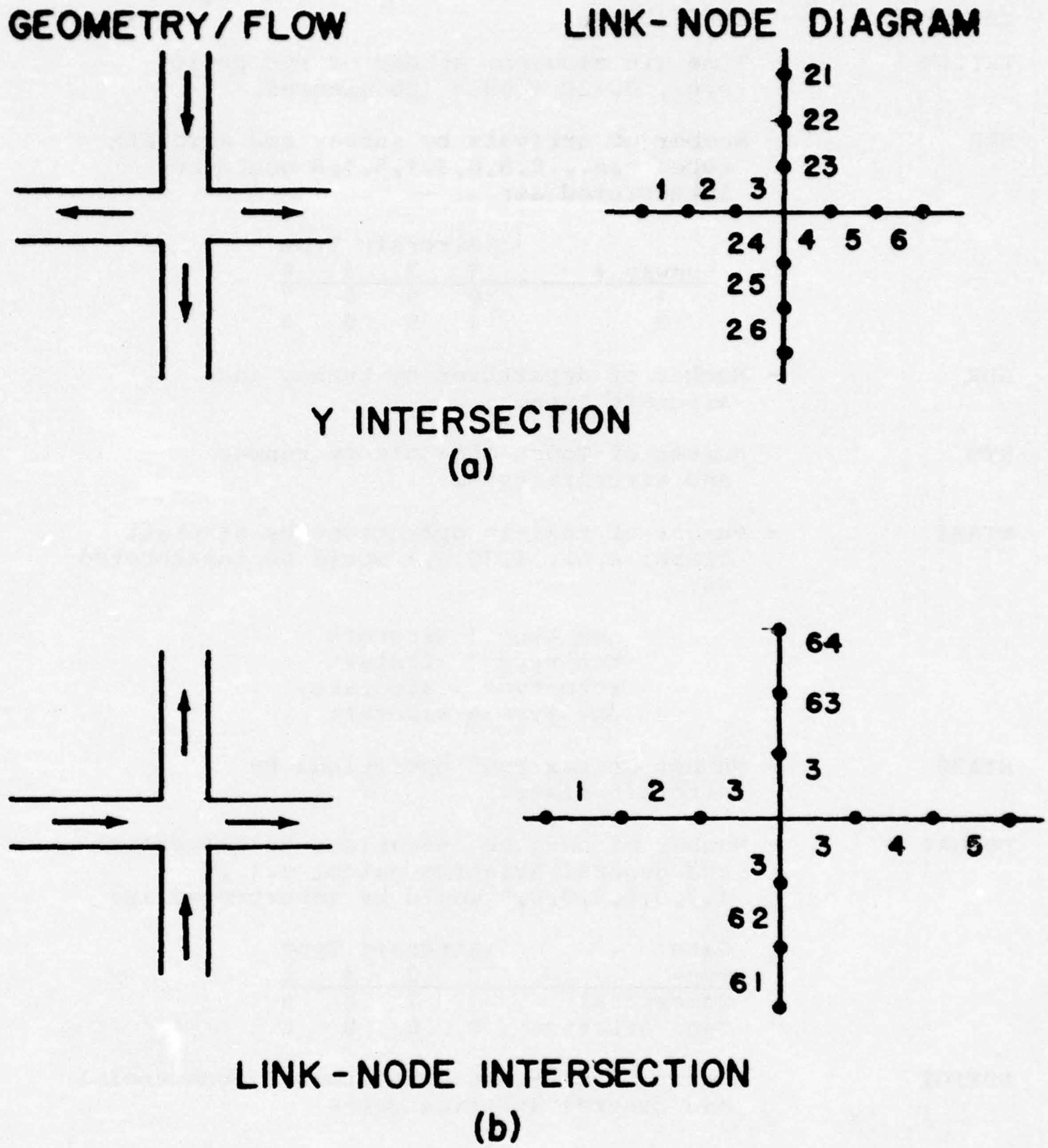
SAMPLE AIRFIELD GEOMENTRY

FIGURE 4-1A



SAMPLE LINK-NODE DIAGRAM

FIGURE 4-1B



Example of Y and LINK-NODE Intersections

Figure 4-2

Variable	Description
TSTTIM	- Time (in minutes) at end of run period; e.g., 0.12E + 03 = 120 minutes.
NAR	- Number of arrivals by runway and aircraft type; e.g., 0,5,0,1,1,5,0,0 would be interpreted as:

Runway #	Aircraft Type 1	2	3	4
1	0	5	0	1
2	1	5	0	0

NDR	- Number of departures by runway and aircraft type.
NTG	- Number of Touch-ang-Go's by runway and aircraft type.
NTAXI	- Number of taxi-in operations by aircraft class; e.g., 1,10,0,1 would be interpreted as:

one type 1 aircraft
ten type 2 aircraft
zero type 3 aircraft
one type 4 aircraft

NTAX0	- Number of taxi-out operations by aircraft class.
NONGAT	- Number of on-gate operations by commercial and general aviation gates; e.g., 1,7,0,0,0,0,0,0 would be interpreted as:

Gate Type	Aircraft Type 1	2	3	4
Commercial	1	7	0	0
Gen. Aviation	0	0	0	0

NOFFGT	- Number of off-gate operations by commercial and general aviation gates.

FIGURE 4-3

FORMAT OF DETAIL HOURLY STATISTICS PRINTOUT

Variable	Description
NRCAR	- Number of arrival runway crossing operations by aircraft type per crossing link; e.g., 0,0,0,0,1,3,0,0 0,1,0,0 would be interpreted as:

Crossing Link	Aircraft Type 1	2	3	4
1	0	0	0	0
2	1	3	0	0
3	0	1	0	0

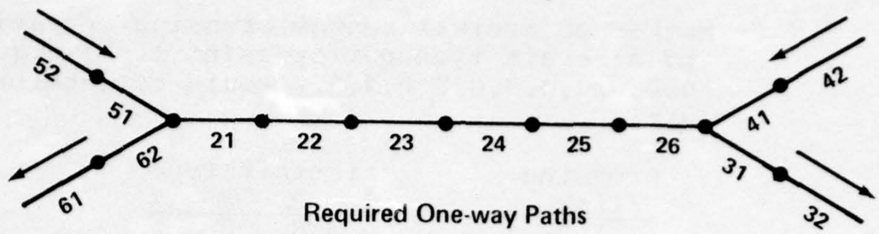
There can be up to 10 crossing links. Crossing link 1 is the first link number entered on the RWY XING LINKS data card.

Variable	Description
NRCDR	- Number of departure runway crossing operations by aircraft type per crossing link.
ARDLY	- Arrival runway delay by aircraft type.
DPDLY	- Departure runway delay by aircraft type.
GDLYAR	- Arrival gate delay.
GDLYDR	- Departure gate delay.
TXIDLY	- Taxi-in delay.
TXODLY	- Taxi-out delay.
RCDAR	- Runway crossing arrival delay.
RCDDP	- Runway crossing departure delay.
AATTM	- Arrival travel time by runway.
ADTTM	- Departure travel time by runway.
NGRUN	- Number of arrival gate operations by runway.

FIGURE 4-3 (Cont.)

FORMAT OF DETAIL STATISTICS PRINTOUT

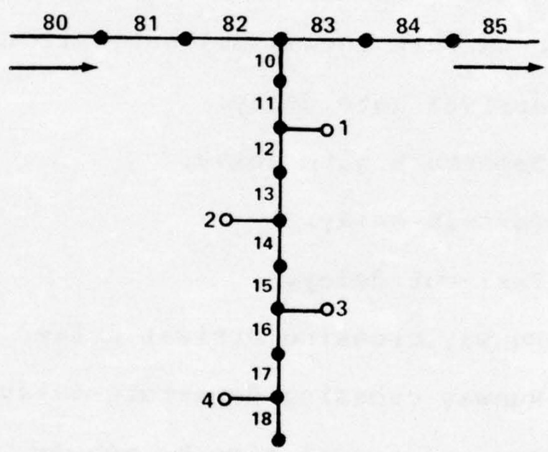
Example 1 - Taxiway



Required One-way Paths

21	22	23	24	25	26
26	25	24	23	22	21

Example 2 - Gate



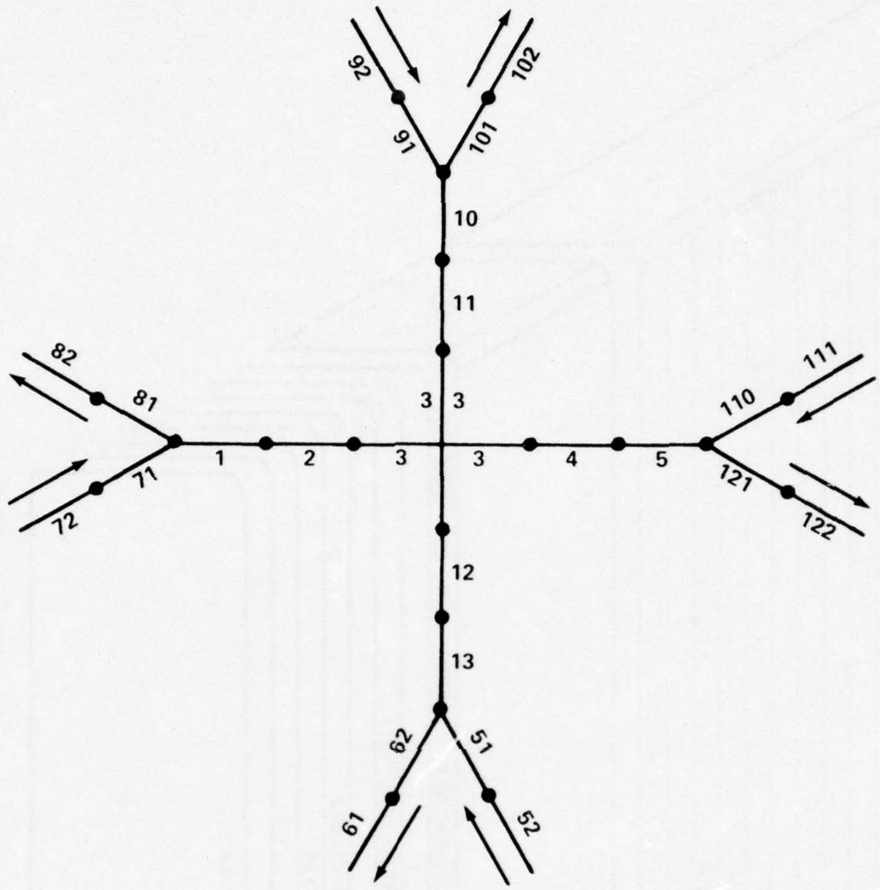
Required One-way Path

10 11 12 13 14 15 16 17 18

Note: This is the Pushback Path for Gates 1, 2, 3 and 4.

FIGURE 4 - 4
EXAMPLES OF ONE-WAY PATHS

Example 3 - Intersecting One-way Paths

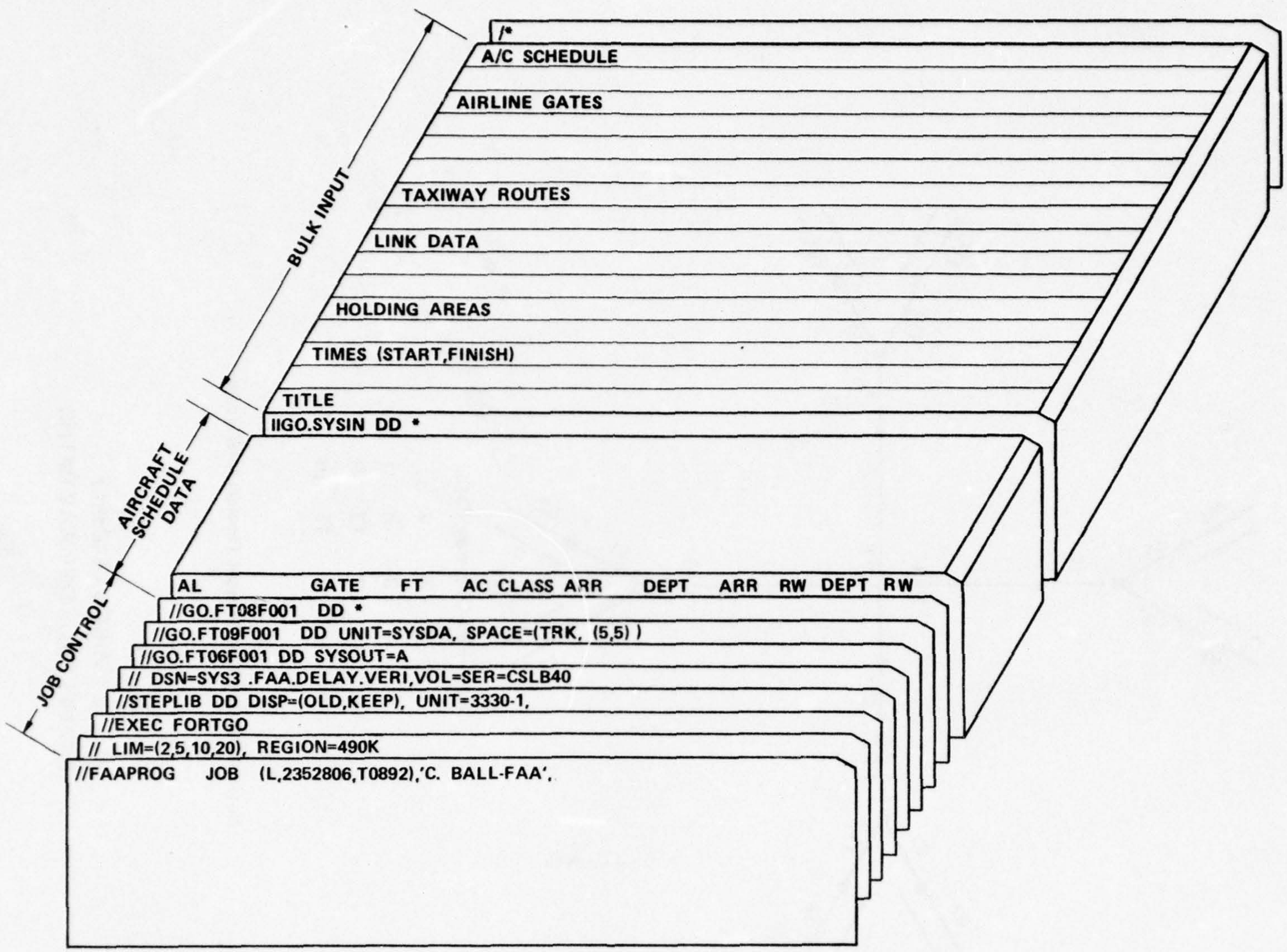


Required One-way Paths

1	2	3	4	5
5	4	3	2	1
10	11	3	12	13
13	12	3	11	10

Note: All Aircraft Go Straight Through Intersection.

FIGURE 4 - 4 (Cont.)
EXAMPLES OF ONE-WAY PATHS



SAMPLE JOB CONTROL DESK
Figure 4-5

DAC 25-1212C (REV 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6

ADMINISTRATIVE

1–8	9–16	17–24	25–32	33–40	41–48	49–56	57–64	65–72	73–80
TITLE									
RANDOM N	UMBER SE	EDS							
# of rn									
rn1 2001	rn2 3002	rn3 4003	rn4 5004	rn5 6005	rn6 7006	rn7 8007	rn8 9008	rn9 5555	rn10 4444
PRINT OP	TIONS								
movement FA	debugging FA	hourly data FA	warnings TR	ac switching FA	queue FA				
TIMES(ST	ART,FINI	SH)							
start	finish								
A/C SCHE	DULE								
PRINT IN	PUT ONLY								
COMPUTE									
STOP									

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

AIRCRAFT CHARACTERISTICS

1–8	9–16	17–24	25–32	33–40	41–48	49–56	57–64	65–72	73–80
TAXIWAY	SPEEDS (	SIX STAN	DARD SPE	EDS)					
ts1 .	ts2 .	ts3 .	ts4 .	ts5 .	ts6 .				
A/C APPR	OACH SPE	EDS							
class #		mean		σ					
1		.		.					
2		.		.					
3		.		.					
-4		.		.					
A/C SERV	ICE TIME	S				(IE GATE	SERVICE	TIME)	
class #		mean		σ					
1		.		.					
2		.		.					
3		.		.					
-4		.		.					
RWY T/GO	OCCUPAN	CY TIMES							
class #		mean		σ					
1		.		.					
2		.		.					
3		.		.					
-4		.		.					
RWY INTE	RARRIVAL	GAP							
	q		gap .						

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

RUNWAY OCCUPANCY TIMES

1–8	9–16	17–24	25–32	33–40	41–48	49–56	57–64	65–72	73–80
RWY ARRI	VAL OCCU	PANCY TI	MES	(IE TIME	VS DIST	ANCE HIS	TOGRAM)		
class #	# of pairs								
1									
dist .	time .	d .	t .	d .	t .	d .	t .	d .	t .
d .	t .	d .	t .	d .	t .	d .	t .	d .	t .
2									
d .	t .	d .	t .	d .	t .	d .	t .	d .	t .
d .	t .	d .	t .	d .	t .	d .	t .	d .	t .
3									
d .	t .	d .	t .	d .	t .	d .	t .	d .	t .
d .	t .	d .	t .	d .	t .	d .	t .	d .	t .
-4									
d .	t .	d .	t .	d .	t .	d .	t .	d .	t .
d .	t .	d .	t .	d .	t .	d .	t .	d .	t .
RWY DEP.	OCCUPAN	CY TIMES							
class #		mean		σ					
1		.		.					
2		.		.					
3		.		.					
-4		.		.					

DAC 25-1212C (REV 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

RUNWAY EXITS

1–8	9–16	17–24	25–32	33–40	41–48	49–56	57–64	65–72	73–80
RWY EXIT	DISTANCES								
# of pairs									
exit link	dist	el	d	el	d	el	d	el	d
el	d	el	d	el	d	el	d	el	d
el	d	el	d	el	d	el	d	el	d
el	d	el	d	el	d	el	d	el	d
el	d	el	d	el	d	el	d	el	d
el	d	el	d	el	d	el	d	el	d
RWY EXIT	SELECTIO	N	(IE PROB	ABILITY	OF AN AI	RCRAFT U	SING AN	EXIT)	
class # 1	rw # 1	# of pairs							
exit link	prob	el	p	el	p	el	p	el	p
2	1								
3	1								
4	1								
1	2								

DAC 25-1212C (REV 8-67)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

RUNWAY EXITS

1–8	9–16	17–24	25–32	33–40	41–48	49–56	57–64	65–72	73–80
class #	rw #	# of pairs							
2	2								
exit link	prob								
	.		.		.		.		.
3	2								
	.		.		.		.		.
4	2								
	.		.		.		.		.
1	3								
		el	p	el	p	el	p	el	p
	.		.		.		.		.
2	3								
	.		.		.		.		.
3	3								
	.		.		.		.		.
4	3								
	.		.		.		.		.
1	4								
	.		.		.		.		.
2	4								
	.		.		.		.		.
3	4								
	.		.		.		.		.

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

RUNWAY EXITS

Columns 1–8	Columns 9–16	Columns 17–24
class # 1-14	rw # 14	# of pairs

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

GEOMETRY DATA

Columns 1–80

RWYS NO. OF
#

RWY NAMES
rw1 rw2 rw3 rw4

RWY END LINKS
rw1 rw2 rw3 rw4

RWY XING LINKS

RUNWAY # LINK #

1

2

3

4

5

6

7.

8

9

HOLDING AREAS
# of ha

ha1 ha2 ha3 ha4 ha5 ha6 ha7 ha8 ha9 ha10

DAC 25 1212C (REV 8-63)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

LINK DATA

Columns 1–8	Columns 9–16	Columns 17–24	Columns 25–32	Columns 33–40	Columns 41–48	Columns 49–56	Columns 57–64	Columns 65–72	Columns 73–80
TAXIWAY	LINKS								
LINK NO.	LINK TY	LENGTH		SPEED		1 WP			

DAC 25-1272C (REV 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

LINK DATA

link no. (1–8)	link ty (9–16)	length (17–24)	(25–32)	speed (33–40)	(41–48)	1 wp (49–56)	(57–64)	(65–72)	(73–80)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

ROUTE DATA (NOTE: ROUTES ARE NOT LIMITED TO 40 LINKS)

Columns 1–80

TAXIWAY ROUTES

# of links

link1

link11

link21

link31

# of links

link1

link11

link21

link31

link41

# of links

link1

link11

link21

link31

link41

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

ROUTE DATA

Columns: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Route
# of links
link1
link11
link21
link31
link41

Route
# of links
link1
link11
link21
link31
link41

Route
# of links
link1
link11
link21
link31
link41

DAC 25-12125 (REV. 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d FIGURE 4-6 (Con't.)

ONE-WAY PATHS

	1–8	9–16	17–24	25–32	33–40	41–48	49–56	57–64	65–72	73–80
	TAXIWAY	ONE-WAY								
lwp 1	# of links									
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
	L11	L12	L13	L14	L15	L16	L17	L18	L19	L20
	L21	L22	L23	L24	L25					
lwp 2	# of links									
lwp 3	# of links									
lwp 4	# of links									
lwp 5	# of links									

DAC 25-1212C (REV 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

ONE-WAY PATHS

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

lwp # of links

lwp # of links

lwp # of links

lwp # of links

lwp # of links

lwp # of links

lwp # of links

DAC 25-1212C (REV 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

APPROACH PATH

RWY LENGTHS OF COMMON APPROACH PATHS

rw # (cols 1–8)	class # (cols 9–16)	length (n.mi.) (cols 17–24)	cols 25–80
1	1	.	
1	2	.	
1	3	.	
1	4	.	
2	1	.	
2	2	.	
2	3	.	
2	4	.	
3	1	.	
3	2	.	
3	3	.	
3	4	.	
4	1	.	
4	2	.	
4	3	.	
-4	4	.	

DAC 25 1212C (REV 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

GATES AND BASING AREAS

1–8	9–16	17–24	25–32	33–40	41–48	49–56	57–64	65–72	73–80
G/A HOLD	ING AREA		(IE GENE	RAL AVIA	TION BAS	ING AREA	S)		
# of									
ba1	ba2	ba3	ba4	ba5	ba6	ba7	ba8	ba9	ba10
AIRLINE	NAMES								
# of al									
AL1	AL2	AL3	AL4	AL5	AL6	AL7	AL8	AL9	AL10
AL11	AL12	AL13	AL14	AL15	AL16	AL17	AL18	AL19	AL20
AIRLINE	GATES								
AL1	# of gates								
g1	g2	g3	g4	g5	g6	g7	g8	g9	g10
g11									g20
AL2	# of gates								
g1									g10
g11									g20
AL3	# of gates								
g1									g10
g11									g20
AL4	# of gates								
g1									
g11									

DAC 25 1212C (REV 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

GATES AND BASING AREAS

1–8	9–16	17–80
AL5	# of gates	
gl		
gll		
AL6	# of gates	
gl		
AL7	# of gates	
gl		
AL8	# of gates	
gl		
AL9	# of gates	
gl		

DAC 25 1212C (REV 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

ARRIVAL-ARRIVAL SEPARATION

ATC SEPARATIONS

A/C SEPARATIONS

FIRST OPERATION OP (col 8)	CLASS (col 16)	RWY (col 24)	SECOND OPERATION OP (col 32)	CLASS (col 40)	RWY (col 48)	MEAN (cols 49–56)	STD (cols 57–64)
arr or dept			arr or dept			n mi	n mi
A	1	1	A	1	1	.	.
A	1	1	A	2	1	.	.
A	1	1	A	3	1	.	.
A	1	1	A	4	1	.	.
A	2	1	A	1	1	.	.
A	2	1	A	2	1	.	.
A	2	1	A	3	1	.	.
A	2	1	A	4	1	.	.
A	3	1	A	1	1	.	.
A	3	1	A	2	1	.	.
A	3	1	A	3	1	.	.
A	3	1	A	4	1	.	.
A	4	1	A	1	1	.	.
A	4	1	A	2	1	.	.
A	4	1	A	3	1	.	.
A	4	1	A	4	1	.	.

DAC 25-1212 (REV. 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d | FIGURE 4-6 (Con't.) | DEPARTURE-DEPARTURE SEPARATION

ATC SEPARATIONS

Cols 1–6	op (7–8)	Cols 9–12	class (13–16)	Cols 17–21	rwy (22–24)	Cols 25–30	op (31–32)	Cols 33–36	class (37–40)	Cols 41–45	rwy (46–48)	Cols 49–52	mean minutes (53–56)	Cols 57–61	std minutes (62–64)	Cols 65–80
	D		1		1		D		1		1		.		.	
	D		1		1		D		2		1		.		.	
	D		1		1		D		3		1		.		.	
	D		1		1		D		4		1		.		.	
	D		2		1		D		1		1		.		.	
	D		2		1		D		2		1		.		.	
	D		2		1		D		3		1		.		.	
	D		2		1		D		4		1		.		.	
	D		3		1		D		1		1		.		.	
	D		3		1		D		2		1		.		.	
	D		3		1		D		3		1		.		.	
	D		3		1		D		4		1		.		.	
	D		4		1		D		1		1		.		.	
	D		4		1		D		2		1		.		.	
	D		4		1		D		3		1		.		.	
	D		4		1		D		4		1		.		.	

DAC 25-1212C (REV 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

DEPARTURE-ARRIVAL SEPARATION

ATC SEPARATIONS

op (cols 7–8)	class (cols 13–16)	rwy (cols 22–24)	op (cols 31–32)	class (cols 37–40)	rwy (cols 46–48)	mean n mi (cols 53–56)	std n mi (cols 62–64)
D	1	1	A	1	1	.	.
D	1	1	A	2	1	.	.
D	1	1	A	3	1	.	.
D	1	1	A	4	1	.	.
D	2	1	A	1	1	.	.
D	2	1	A	2	1	.	.
D	2	1	A	3	1	.	.
D	2	1	A	4	1	.	.
D	3	1	A	1	1	.	.
D	3	1	A	2	1	.	.
D	3	1	A	3	1	.	.
D	3	1	A	4	1	.	.
D	4	1	A	1	1	.	.
D	4	1	A	2	1	.	.
D	4	1	A	3	1	.	.
D	4	1	A	4	1	.	.

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d FIGURE 4-6 (Con't.) ARRIVAL-ARRIVAL SEPARATION

ATC SEPARATIONS

1–6	7–8 op	9–16 class	17–24 rwy	25–32 op	33–40 class	41–48 rwy	49–56 mean n mi	57–64 std n mi	65–72	73–80
	A	1		A	1		.	.		
	A	1		A	2		.	.		
	A	1		A	3		.	.		
	A	1		A	4		.	.		
	A	2		A	1		.	.		
	A	2		A	2		.	.		
	A	2		A	3		.	.		
	A	2		A	4		.	.		
	A	3		A	1		.	.		
	A	3		A	2		.	.		
	A	3		A	3		.	.		
	A	3		A	4		.	.		
	A	4		A	1		.	.		
	A	4		A	2		.	.		
	A	4		A	3		.	.		
	A	4		A	4		.	.		

DAC 25-1212C (REV 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

ARRIVAL-DEPARTURE SEPARATION

ATC SEPARATIONS

1–8 op	9–16 class	17–24 rwy	25–32 op	33–40 class	41–48 rwy	49–56 mean (minutes)	57–64 std (minutes)	65–72	73–80
A	1		D	1		.	.		
A	1		D	2		.	.		
A	1		D	3		.	.		
A	1		D	4		.	.		
A	2		D	1		.	.		
A	2		D	2		.	.		
A	2		D	3		.	.		
A	2		D	4		.	.		
A	3		D	1		.	.		
A	3		D	2		.	.		
A	3		D	3		.	.		
A	3		D	4		.	.		
A	4		D	1		.	.		
A	4		D	2		.	.		
A	4		D	3		.	.		
A	4		D	4		.	.		

DAC 25-1212C (REV 8-69)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d — FIGURE 4-6 (Con't.) — DEPARTURE-DEPARTURE SEPARATION

ATC SEPARATIONS

1–8 op	9–16 class	17–24 rwy	25–32 op	33–40 class	41–48 rwy	49–56 mean (minutes)	57–64 std (minutes)	65–72	73–80
D	1		D	1		.	.		
D	1		D	2		.	.		
D	1		D	3		.	.		
D	1		D	4		.	.		
D	2		D	1		.	.		
D	2		D	2		.	.		
D	2		D	3		.	.		
D	2		D	4		.	.		
D	3		D	1		.	.		
D	3		D	2		.	.		
D	3		D	3		.	.		
D	3		D	4		.	.		
D	4		D	1		.	.		
D	4		D	2		.	.		
D	4		D	3		.	.		
D	4		D	4		.	.		

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

DEPARTURE-ARRIVAL SEPARATION

ATC SEPARATIONS

op (7-8)	class (12-16)	rwy (22-24)	op (31-32)	class (36-40)	rwy (46-48)	mean (53-56) n mi	std (62-64) n mi
D	1		A	1		.	.
D	1		A	2		.	.
D	1		A	3		.	.
D	1		A	4		.	.
D	2		A	1		.	.
D	2		A	2		.	.
D	2		A	3		.	.
D	2		A	4		.	.
D	3		A	1		.	.
D	3		A	2		.	.
D	3		A	3		.	.
D	3		A	4		.	.
D	4		A	1		.	.
D	4		A	2		.	.
D	4		A	3		.	.
D	4		A	4		.	.

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d FIGURE 4-6 (Con't.)

AIRCRAFT SCHEDULE DATA (NOTE: THIS DATA MUST BE STORED IN A FILE ON UNIT 8.)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

AL GATE FT AC CLASS ARR DEPT ARR RW DEPT RW

DAC 25-1212C (REV 8-64)

CODING FORM FOR THE DELAY SIMULATION MODEL VERSION 2d

FIGURE 4-6 (Con't.)

AIRCRAFT SCHEDULE DATA (NOTE: THIS DATA MUST BE STORED IN A FILE ON UNIT 8.)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

al gate ft ac class arr dept arr rw dept rw

COLUMN	DESCRIPTION
1	Aircraft number used by program. Numbers are assigned according to the order in input schedule. Because of lateness distribution, aircraft may not land in same order as input schedule.
2	Assigned gate number when data for an arriving aircraft is first printed. Thereafter, it is the assigned path number from exit to gate. For departures, it is the path number from gate to departure link.
3	Flight type
4	Aircraft type
5	Assigned Gate
6	Current link (defined by location number) occupied by airplane. Location number 0 means no path has been assigned yet.
7	Aircraft state
8	Arrival time at threshold.
9	Assigned gate service time
10	Gate departure time
11	Current time (hour, minute, second); i.e., the time when the aircraft desires to move.
12	Current link number (same number as used in link node diagram). A link number of 0 means no path has been assigned yet.

FIGURE 4-7

FORMAT OF DETAIL MOVEMENT PRINTOUT

5.1 Introduction

An analytic model has been developed to compute:

a) Total annual delay.

b) Average delay per aircraft over a year.

c) The distribution of aircraft delays over a year.

The Annual Delay Model automates the manual process for determining annual delay described in reference b. The Annual Delay Model computes the delay in representative hours and aggregates them into measures of annual delay according to their frequency of occurrence. In doing this the model considers fluctuations of:

a) Weather (IFR & VFR)
b) Runway use configuration
c) Hourly capacity
d) Hourly demand

5.2 Model Logic

The Annual Delay Model takes a specified annual demand and apportions it into representative hourly demands. This is done using three distributions of demand; i.e.

Week Group Distribution of Demand - PWEEK(i)
Day Group Distribution of Demand - PDAY(j)
Hourly Distribution of Demand - PHOUR(k)

A week group is a set of weeks (or fractions of a week) that have similar demand and weather charateristics. Monthly data can be entered as 4 and a fraction weeks; e.g., 31 days = 4.43 weeks. The week group distribution of demand provides the proportion of the annual demand that occurs in each week of a week group.

A day group is a set of days within a week that have similar demand characteristics. Each day of the week may be accounted for separately or days may be grouped together. The day group distribution of demand provides the proportion of the weekly demand that occurs in each day of a day group.

The hourly distribution of demand provides the proportion of the daily demand that occurs in each hour. The hourly demand for a representative hour of the year is given by:

$$HD(i,j,k) = \frac{\text{ANNUAL DEMAND}}{NWEEK(i) \cdot PWEEK(i) \cdot NDAY(j) \cdot PDAY(j) \cdot PHOUR(k)}$$

where: HD(i,j,k) = hourly demand for week group i, day group j, and hour group k.

NWEEK(i) = number of weeks in each week group.

NDAY(j) = number of days in each day group.

The representative hourly demand may be further adjusted to account for demand restrictions imposed by weather conditions and/or runway use configuration.

Hourly capacities are input for each runway use configuration and weather category combination. Hourly delays are calculated for each representative hour of the year and weather category using the delay curves given in Figure 2-68 of reference b. The average delay per operation for the year is computed considering the frequency of occurance of each representative hour, each weather condition, and each runway use configuration.

NOTE: In calculating hourly delay, the model assumes that all capacity and demand values are for 50% arrival.

5.3 Input Format

The following general instructions apply to preparing inputs to the Annual Delay Model:

1. Data entry requires two types of cards; i.e.,

   Header Card; e.g., WEAPCT 8

   Data Card(s); e.g., 0.82 0.64
   0.18 0.36

   (NOTE: 8 is the data type number. See 7. below.)

2. There is no fixed sequence for groups of header/data cards except:

   a) the card containing KRUN and I-PRINT data must be the first card in the deck, and

   b) Data type 2; i.e., GROUPS, must precede data types 3, 4, 5, 6, 7, 8, 9, 10, 13, 14 and 15.

3. Unless otherwise noted on the form by decimal points, right justify numbers within the blocks shown on the coding form.

4. To execute a run, place a 1 in card column 14 of the header card for the last data group.

5. Multiple runs can be made with one stack of cards. Place replacement header/data cards after the execute card for the first complete run. This procedure is illustrated in example 1.

6. Any 10 letter title can be used in card columns 1-10 of the header card.

7. On the header card:

cc	1-10	Title
cc	11-12	Data type number
cc	14	Execute command (i.e., 1)

8. The model can accommodate:

52 week groups
7 day groups
10 weather groups
10 runway use configurations

The coding form in this chapter is constructed for up to 12 week groups and two weather groups.

9. Enter annual demand as 325000 not 325,000 or 325K.

10. Whenever a proportion or ratio is called for, the input should be entered as a decimal; e.g., 0.017 not 1.7%.

11. Allowable values of Demand Profile Factor are 25, 30, 35, 40, 45 and 50.

A sample coding form with header labels and decimal points is shown in Figure 5-1. It is recommended that a similar form be used in preparing card inputs. The definitions of terms used in the coding form are given below:

TERM	DEFINITION
KRUN	The number of runs to be executed. The value of KRUN is equal to the number of occurance of a 1 in card column 14 of the header card.
I-PRINT	If I-PRINT = 1, the input data will be listed before the output is printed. If I-PRINT = 0, no input data will be listed.
ANNDEMAND	A header label used with annual demand data.
ANNDEM	The annual demand in operations per year.

GROUPS	A header label used with the specification of group data.
NDGPS	Number of day groups.
NWGPS	Number of week groups.
NWECON	Number of weather conditions.
NRWUSE	Number of runway use configurations.
WKPERCENT	A header label used with the proportion of total annual traffic that occurs in one week of each week group; e.g., if total annual traffic = 350000 and demand in 1 week of a week group = 7350, the proportion = 0.021.
WG1 thru WG12	Week group 1 thru 12.
WKNUMBER	A header label used with the number of weeks in each week group.
CAPACITY	A header label used with the hourly runway capacity for each runway use configuration and weather combination.
WE1	Weather group 1.
WE2	Weather group 2.
DPERCENT	A header label used with the proportion of weekly traffic that occurs in 1 day of each day group; e.g., if weekly traffic = 6000 operations and the demand in 1 day of a day group = 875, the proportion = 0.146.
DG1 thru DG7	Day groups 1 thru 7.
DAYNUMBER	A header label used with the number of days in each day group.
DEMANPCT	A header label used with weather group demand factors; i.e., the ratio of demand in each weather group to the demand in WE1.
WEAPCT	A header label used with the proportion of occurrence of each weather group in any given week group.
DEMPROFILE	A header label used with Demand Profile Factor.
DPF	Demand Profile Factor
RWYDEMPCT	A header label used with runway use configuration demand factor; i.e., the ratio of demand

	for each runway use configuration to the dema for RU1.
RU1 thru RU10	Runway use configuration number 1 thru 10.
RUNID	A header label used with title information.
TITLE	Any 20 letter name identifying the run; e.g., NATIONAL 1987 CASE 3
HOURPCT	A header label used with the proportion of daily traffic in each hour; e.g., if the dail traffic = 800 and the demand in hour HR7 = 60 the proportion for HR7 = 0.075.
HR1 thru HR24	Hour 12:00 a.m. - 12:59 a.m. through 11:00 p. - 11:59 p.m.
FIGNUMS	A header label used with the figure numbers given in Figure 5-1.

5.4 Input Considerations

The following factors should be considered in preparing inputs to the Annual Delay Model:

a. The sequence in which week group proportions are entered is not important. However, they must be coordinated with the annual weather distribution.

b. The input weather distribution represents the proportion of the days where that weather condition exists all day. The proportion of the days which are WE1 or WE2 should not include weather conditions which occur during very low demand periods of the day; e.g., do not include in this proportion days during which the bad weather only occurs between 10:00 p.m. and 5:00 a.m.

c. The sequence in which day group proportions are entered has no impact on annual delay. The important data is the magnitude of the numbers. The Annual Delay Model assumes that every week of each month has the same daily demand distribution.

d. The sequence in which hourly proportions are entered is very important, if demand exceeds capacity for several consecutive hours for some runway use configuration/weather combination.

e. It is recommended that only runway use configurations that occur for at least 5% of a given weather condition be considered in the annual delay analysis.

f. The Demand Profile Factor is defined as the percent of the hourly demand that occurs in the peak 15 minutes. To consider the variations of the Demand Profile Factor from hour to hour, input the average Demand Profile Factor for the busy hours of the day.

g. Touch-and-go operations do not normally occur during busy hours at commercial airports. Touch-and-go operations should be excluded from the annual operations when determining annual delay for commercial airports. If touch-and-go operations are included as part of the input for a general aviation airport, the hourly capacities should be based on the same percent touch-and-go. The Annual Delay Model treats touch-and-go operations as one arrival and one departure. If a runway use configuration consists of one runway used exclusively for touch-and-go operations and one runway for arrival and departure operations, the annual delay analysis should be done separately for each runway.

5.5 Output

The output of the Annual Delay Model consists of:

a) total annual delay in minutes,

b) average delay per operation in minutes, and

c) distribution of annual delay.

The distribution of annual delay is computed and listed by time interval. The output format is:

Time Interval		Percent of Operations
0.0	0.2	
0.2	0.4	
0.4	0.6	
.		
.		
.		
1.8	2.0	
2.0	3.0	
3.0	4.0	
.		
.		
.		
99.0	100.0	
Over 100.0		

The time interval is not printed if it had 0% of the aircraft delays.

5.6 Optional Outputs

The Annual Delay Model can be used to calculate:

the delay for an hour,
the delay for a series of hours,
the delay for a day,
the delay for a week,
the delay for a month, and
measures of annual capacity.

The following defines procedures for determining these outputs:

a. Hourly Delay. The delay for a given hour can be determined by completing the partially filled in form shown in Figure 5-2. The value of annual demand should be equal to hourly demand x 365. Set HR1 = 1.0 for header label HOURPCT. The model output of average delay per operation is the average delay per operation for the hour under consideration.

b. Delay for a Series of Consecutive Hours. The delay for 2 or more consecutive hours up to 24 hours can be determined by completing the partially filled in form shown in Figure 5-2. The value of annual demand should be equal to the total hourly demand for the series of hours x 365.

The model output of average delay per operation is the average delay per operation over the time span considered.

c. Daily Delay. The average delay per operation for a day can be determined by following the procedure defined by b. above using an hourly demand distribution for the complete 24-hour period.

d. Weekly Delay. The average delay per operation for a particular week can be determined by computing the daily delay for the conditions specific to each day (or group of days) of the week.

e. Monthly Delay. The average delay per operation for a particular month can be determined by computing the daily delay for the conditions specific to each day (or group of days) of the month.

f. Measures of Annual Capacity. The Annual Delay Model can be used to determine a level of service of annual capacity based on:

1) The average delay per operation produced by a given number of annual operations.

2) The percent of annual operations having delays in excess of some selected delay per operation.

3) Some combination of the above.

The procedure is to operate the model at different values of annual operations but keeping all other inputs fixed. The model output can then be analyzed to determine annual capacity based on the level of service desired by the user.

5.7 <u>Data Input Modes</u> It is possible to use the Annual Delay Model in two input modes; i.e.,

- o Remote Job Entry (RJE) via cards
- o From a teletype terminal using stored files

Remote job entry requires that all data be punched on IBM cards and be processed by a card reader. Job cards are required to load the capacity model and to identify the user for billing purposes. Model output is printed on a remote printer.

In the teletype terminal mode the user can construct input files and call for model executions directly from the teletype location. The input format is exactly the same as with cards. To call for an execution, a series of computer instructions are entered from the teletype terminal. These instructions can be stored in the computer and called for by a Command File or CLIST. The FAA has established Command Files on TYMSHARE and McAuto for operation of the Annual Delay Model from a teletype terminal. To use this method requires that the input data be placed in a temporary file named BATCH.SUB and that the command EX TER AND be entered. The result will be a complete execution of the Annual Delay Model. After execution, the input file BATCH.SUB can be renamed and permanently stored, or edited and reexecuted.

5.8 <u>Examples</u>

The following examples illustrate the use of the Annual Delay Model Version 1.

<u>Example 1</u>

Compute the total delay for the following conditions:

Annual Demand: 300,000 and 400,000 operations
Percent Arrival: 50
Percent Touch-and-Go: 0
Demand Profile Factor: 35
WE1 = VFR

WE2 = IFR
WE2 Demand = 90% of WE1 demand
RU2 = 110% of RU1
RU3 = 110% of RU1

Annual Demand Distribution

January	.087	July	.081
February	.087	August	.080
March	.082	September	.082
April	.081	October	.087
May	.080	November	.088
June	.076	December	.089

Annual Weather Distribution

	WE1	WE2		WE1	WE2
January	1.00	0.00	July	.98	.02
February	.99	.01	August	.99	.01
March	.98	.02	September	.99	.01
April	.99	.01	October	1.00	0.00
May	.98	.02	November	1.00	0.00
June	.98	.02	December	1.00	0.00

Daily Demand Distribution

Monday	.15	Friday	.15
Tuesday	.13	Saturday	.14
Wednesday	.14	Sunday	.15
Thursday	.14		

Hourly Demand Distribution

0-1	0.59	6-7	0.32	12-13	4.32	18-19	9.80
1-2	0.47	7-8	2.50	13-14	5.18	19-20	10.66
2-3	0.23	8-9	8.63	14-15	3.77	20-21	6.86
3-4	0.17	9-10	7.13	15-16	4.18	21-22	2.91
4-5	0.08	10-11	3.34	16-17	7.84	22-23	1.66
5-6	0.12	11-12	6.01	17-18	12.21	23-24	1.02

Hourly Capacity Data in Weather Condition 1

Runway Use	Runway Geometry	Figure Number	Mix Index	Hourly Capacity	Percent Utilization
1	Single RW	2-3	140	52	10
2	Parallel RW	2-4	140	72	30
3	Parallel RW	2-9	140	95	60

Hourly Capacity Data in Weather Condition 2

Runway Use	Runway Geometry	Figure Number	Mix Index	Hourly Capacity	Percent Utilization
2	Parallel RW	2-44	160	60	70
1	Single RW	2-43	160	50	30

Figure 5-3 shows the coding form for this problem with input data filled in. From the computer output shown in Figure 5-4, the total delay is found to be:

Annual Demand (Operations)	Annual Delay (Hours)
300,000	27,532
400,000	148,000

Example 2

Compute the average delay per operation for the following day.

Hourly Demand Distribution

Hour	Demand	Proportion
0-1	2	0.003
1-2	1	0.002
2-3	0	0.000
3-4	0	0.000
4-5	0	0.000
5-6	3	0.005
6-7	10	0.015
7-8	30	0.045
8-9	40	0.061
9-10	45	0.068
10-11	40	0.061
11-12	30	0.045
12-13	30	0.045
13-14	25	0.038
14-15	45	0.068
15-16	60	0.091
16-17	65	0.099
17-18	55	0.083
18-19	45	0.068
19-20	50	0.076
20-21	30	0.046
21-22	30	0.046
22-23	20	0.030
23-24	3	0.005
TOTAL	659	1.000

Use the single runway IFR data in Example 1 for all other inputs.

Figure 5-5 shows the coding form for this problem with the input data filled in. From the computer output shown in Figure 5-6 the average daily delay per operation is 7.2 minutes.

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

FIGURE 5-1

1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65
k r u n	i-print											
R U N I D		1 6										
title												
A N N D E	M A N D	1										
ann dem												
D E M P R	O F I L E	1 2										
dpf												
G R O U P	S	2										
ndgps	nwgps	nwecon	nrwuse									
W K P E R	C E N T	3										
wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12	
0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	
W K N U M	B E R	4										
wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12	
.	.	.	.	.	.	.	.	.	.	.	.	
D P E R C	E N T	5										
dg1	dg2	dg3	dg4	dg5	dg6	dg7						
0 .	0 .	0 .	0 .	0 .	0 .	0 .						
D A Y N U	M B E R	6										
dg1	dg2	dg3	dg4	dg5	dg6	dg7						
H O U R P	C T	1 1										
hr1	hr2	hr3	hr4	hr5	hr6	hr7	hr8	hr9	hr10	hr11	hr12	
0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	
hr13	hr14	hr15	hr16	hr17	hr18	hr19	hr20	hr21	hr22	hr23	hr24	
0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

FIGURE 5-1

	WEAPCT		8									
	wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12
we1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
we2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	DEMANPCT		7									
	we1	we2										
	1.0	.										
	RWYUSEPCT		10									
	we1	we2										
ru1	0.	0.										
ru2	0.	0.										
ru3	0.	0.										
ru4	0.	0.										
ru5	0.	0.										
ru6	0.	0.										
ru7	0.	0.										
ru8	0.	0.										
ru9	0.	0.										
ru10	0.	0.										
	RWYDEMPCT		13									
	ru1	ru2	ru3	ru4	ru5	ru6	ru7	ru8	ru9	ru10		
	1.0	.	.	.	.	.	.	.	.	.		

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

FIGURE 5-1

CAPACITY 9

	we1	we2
ru1	.	.
ru2	.	.
ru3	.	.
ru4	.	.
ru5	.	.
ru6	.	.
ru7	.	.
ru8	.	.
ru9	.	.
ru10	.	.

MIX INDEX 14

ru1	
ru2	
ru3	
ru4	
ru5	
ru6	
ru7	
ru8	

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

FIGURE 5-1

	wel (1–5)	we2 (6–10)	11–15
ru9			
ru10			
	FIG N	UMS	15
	wel	we2	
ru1	2 -	2 -	
ru2	2 -	2 -	
ru3	2 -	2 -	
ru4	2 -	2 -	
ru5	2 -	2 -	
ru6	2 -	2 -	
ru7	2 -	2 -	
ru8	2 -	2 -	
ru9	2 -	2 -	
ru10	2 -	2 -	

CODING FORM FOR OPTIONAL USES OF THE ANNUAL DELAY MODEL VERSION 1

FIGURE 5-2

Columns 1–65

k r u n | i-print

RUNID 16
title

ANNDEMAND 1
ann dem

DEMPROFILE 12
dpf

HOURPCT 11

hr1	hr2	hr3	hr4	hr5	hr6	hr7	hr8	hr9	hr10	hr11	hr12
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
hr13	hr14	hr15	hr16	hr17	hr18	hr19	hr20	hr21	hr22	hr23	hr24
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

CAPACITY 9
wel
rul .0

MIX INDEX 14
wel
rul

FIG NUMS 15
wel
rul

GROUPS 2

ndgps	nwgps	nwecon	nrwuse
1	1	1	1

WKPERCENT 3
wgl
1.0

CODING FORM FOR OPTIONAL USES OF THE ANNUAL DELAY MODEL VERSION 1

FIGURE 5-2

Columns 1–11	Column 12
WKNUMBER	4
wgl	
52.0	
DPERCENT	5
dgl	
1.0	
DAYNUMBER	6
dgl	
365	
WEAPCT	8
wgl	
1.0	
DEMANPCT	7
wel	
1.0	
RWYUSEPCT	10
wel	
1.0	
RWYDEMPCT	13
rul	
1.0	

wel

rul

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1 — COMPLETED CODING FORM FOR EXAMPLE 1 — FIGURE 5-3

Card	Fields
krun / i-print	krun = 2; i-print = 1
RUNID 16	title: EXAMPLE 1
ANNDEMAND 1	ann dem: 4000000
DEMPROFILE 12	dpf: 35
GROUPS 2	ndgps: 7; nwgps: 12; nwecon: 2; nrwuse: 3

WKPERCENT 3

wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12
0.019	0.022	0.018	0.019	0.018	0.018	0.018	0.018	0.019	0.020	0.021	0.020

WKNUMBER 4

wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12
4.43	4.00	4.43	4.28	4.43	4.28	4.43	4.43	4.28	4.43	4.28	4.43

DPERCENT 5

dg1	dg2	dg3	dg4	dg5	dg6	dg7
0.15	0.13	0.14	0.14	0.15	0.14	0.15

DAYNUMBER 6

dg1	dg2	dg3	dg4	dg5	dg6	dg7
1	1	1	1	1	1	1

HOURPCT 11

hr1	hr2	hr3	hr4	hr5	hr6	hr7	hr8	hr9	hr10	hr11	hr12
0.006	0.005	0.002	0.002	0.001	0.001	0.003	0.025	0.086	0.071	0.033	0.060

hr13	hr14	hr15	hr16	hr17	hr18	hr19	hr20	hr21	hr22	hr23	hr24
0.043	0.052	0.038	0.042	0.078	0.122	0.098	0.107	0.069	0.029	0.017	0.010

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1 — COMPLETED CODING FORM FOR EXAMPLE 1 — FIGURE 5-3

WEAPCT 8

	wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12
we1	1.0	0.99	0.98	0.99	0.98	0.98	0.98	0.99	0.99	1.0	1.0	1.0
we2	0.0	0.01	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.0	0.0	0.0

DEMANPCT 7

we1	we2
1.0	0.9

RWYUSEPCT 10

	we1	we2
ru1	0.10	0.30
ru2	0.30	0.70
ru3	0.60	0.0
ru4	0.	0.
ru5	0.	0.
ru6	0.	0.
ru7	0.	0.
ru8	0.	0.
ru9	0.	0.
ru10	0.	0.

RWYDEMPCT 13

ru1	ru2	ru3	ru4	ru5	ru6	ru7	ru8	ru9	ru10
1.0	1.1	1.1	.	.	.	.	.	.	.

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MODEL USER'S MANUAL FOR AIRFIELD CAPACITY AND DELAY MODELS. BOO--ETC(U)
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3 OF 8

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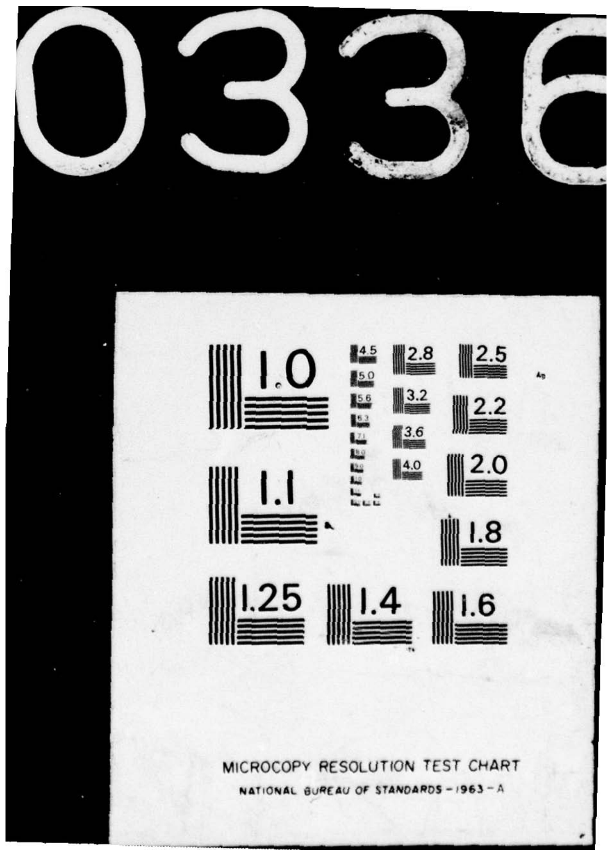
0336
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS - 1963 - A

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

COMPLETED CODING FORM FOR EXAMPLE 1

FIGURE 5-3

	CAPACITY		9
	we1	we2	
ru1	52.	50.	
ru2	72.	60.	
ru3	95.	0.	
ru4	.	.	
ru5	.	.	
ru6	.	.	
ru7	.	.	
ru8	.	.	
ru9	.	.	
ru10	.	.	
	MIX INDEX		14
ru1	140	160	
ru2	140	160	
ru3			
ru4			
ru5			
ru6			
ru7			
ru8			

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

COMPLETED CODING FORM
FOR EXAMPLE 1

FIGURE 5-3

	1–5	6–10	11–15
	~~we1~~	~~we2~~	
ru9			
ru10			
	FIG N	UMS	15 1
	we1	we2	
ru1	2-03	2-43	
ru2	2-04	2-43	
ru3	2-09	2-	
ru4	~~2-~~	~~2-~~	
ru5	~~2-~~	~~2-~~	
ru6	~~2-~~	~~2-~~	
ru7	~~2-~~	~~2-~~	
ru8	~~2-~~	~~2-~~	
ru9	~~2-~~	~~2-~~	
ru10	~~2-~~	~~2-~~	
	ANNDE	MAND	1 1
	300	0.00	

CODING FORM FOR OPTIONAL USES OF THE ANNUAL DELAY MODEL VERSION 1 — COMPLETED CODING FORMS FOR EXAMPLE 2 — FIGURE 5-4

Columns 1–63

Card	Field	Value
krun	krun	2
	l-print	1
RUNID		16
	title	EXAMPLE 2
ANNDEMAND		1
	ann dem	240535
DEMPROFILE		12
	dpf	35
HOURPCT		11
	hr1	0.003
	hr2	0.002
	hr3	0.
	hr4	0.
	hr5	0.
	hr6	0.005
	hr7	0.015
	hr8	0.045
	hr9	0.061
	hr10	0.068
	hr11	0.061
	hr12	0.045
	hr13	0.045
	hr14	0.038
	hr15	0.068
	hr16	0.091
	hr17	0.099
	hr18	0.083
	hr19	0.068
	hr20	0.076
	hr21	0.046
	hr22	0.046
	hr23	0.030
	hr24	0.005
CAPACITY		9
rul	wel	50.0
MIX INDEX		14
rul	wel	160
FIG NUMS		15
rul	wel	21-143
GROUPS		2
	ndgps	1
	nwgps	1
	nwecon	1
	nrwuse	1
WKPERCENT		3
	wgl	1.0

CODING FORM FOR OPTIONAL USES OF THE ANNUAL DELAY MODEL VERSION 1

COMPLETED CODING FORMS
FOR EXAMPLE 2

FIGURE 5-4

Columns 1–10	Columns 11–14
WKNUMBER	4
wgl	
52.0	
DPERCENT	5
dgl	
1.0	
DAYNUMBER	6
dgl	
365	
WEAPCT	8
wgl	
1.0	
DEMANPCT	7
wel	
1.0	
RWYUSEPCT	10
wel	
1.0	
RWYDEMPCT	13
rul	
1.0	

wel

rul

CHAPTER 6 - ON-LINE ANNUAL DELAY MODEL VERSION 1 - ANNUAL DELAY

6.1 Introduction

The On-line Annual Delay Model Version 1 is an adaptation of the general Annual Delay Model described in Chapter 5. It is similar in operation to the On-line Runway Capacity Model discussed in Chapter 3.

The On-line Annual Delay Model provides a structured way to determine the total delay to runway operations for a year. The On-line Annual Delay Model considers the distribution of hourly demand over a 24-hour day, the daily distribution of demand over a 7-day week, the monthly distribution of demand over a year, and the monthly distribution of three weather categories over a year. The On-line Annual Delay Model can be run with user supplied data or a combination of user supplied and built-in data.

A list of computer services (or timesharing companies) offering the program can be obtained from:

Chief, Airport Design Branch, ARD-410
DOT/FAA
2100 Second Street, S.W.
Washington, D.C. 20590

(202) 426-3685

6.2 Discussion of Terms Used by On-line Annual Delay Model

a. Monthly Distribution of Annual Operations. The monthly distribution of annual operations is defined as the percent of annual operations that occur in each month.

The On-line Annual Delay Model has seven built-in distributions of annual operations. These are identified by annual operations distribution letters:

- a Uniform distribution; i.e., the same percentage each month.
- b Based on large air carrier airports with small monthly variations of demand.
- c Based on large air carrier airports with moderate monthly variations of demand.
- d Based on large air carrier airports with substantial monthly variations of demand.

e Based on large general aviation airports with small monthly variations of demand.

f Based on large general aviation airports with moderate monthly variations of demand.

g Based on medium size general aviation airports with substantial monthly variations of demand.

When possible, it is desirable to use site specific annual operation distributions. A monthly summary of total operations by airport can be obtained by contacting:

Information Operations Branch, AMS-220
DOT/FAA
800 Independence Ave., S.W.
Washington, D.C. 20590

(202) 426-3791

More detail data containing the daily tower count can be obtained by contacting:

Aviation Forecast Branch, AVP-120
DOT/FAA
800 Independence Ave., S.W.
Washington, D.C. 20590

(202) 426-3103

The sequence in which monthly percents are entered is not important. However, the distribution of annual operations must be coordinated with the annual weather distribution.

b. Monthly Distribution of Weather. The monthly distribution of weather is defined as the percent of the time that VFR, IFR and PVC operating conditions occur each month.

The On-line Annual Delay Model has four built-in distributions of weather. These are identified by annual weather distribution letters.

a 99% VFR, 1% IFR, 0% PVC
b 95% VFR, 4% IFR, 1% PVC
c 88% VFR, 11% IFR, 1% PVC
d 80% VFR, 18% IFR, 2% PVC

When possible, it is desirable to use site specific weather distributions. Monthly weather data can be obtained from the National Weather Records Center in Ashville, North Carolina.

The input weather percentages represent the percent of the days where that weather condition exists all day. Therefore, the

percent of the days which are VFR, IFR, and PVC should not include weather conditions which only occur during very low demand periods of the day; e.g., do not include in this proportion days during which the bad weather only occurs between 10:00 p.m. and 5:00 a.m.

c. Daily Demand Distribution. The daily demand distribution is defined as the percent of the weekly demand that occurs in each day.

The On-line Annual Delay Model has six built-in distributions of daily demand. These are identified by daily demand distribution letters.

- a Same demand per day
- b Peak day = 1.15 x (minimum day)
- c Peak day = 1.25 x (minimum day)
- d Peak day = 1.50 x (minimum day)
- e Peak day = 1.70 x (minimum day)
- f Two days each with 25% of the weeks demand, the other five days each have 10%

When possible, it is desirable to use site specific daily demand distributions. Data on the daily distribution of demand is contained in "Tower Airport Statistics Handbook" published annually by:

Chief, Aviation Forecast Branch, AVP-120
DOT/FAA
800 Independence Ave., S.W.
Washington, D.C. 20590

(202) 426-3103

The sequence in which the daily demand distribution percentages are entered has no impact on annual delay. The important data is the magnitude of the seven numbers. The Annual Delay Model assumes that every week of each month has the same daily demand distribution.

d. Hourly Demand Distribution. The hourly demand distribution is defined as the percent of the daily demand that occurs in each hour.

The On-line Annual Delay Model has nine built-in distributions of hourly demand. These are identified by hourly demand distribution letters.

- a Uniform over 16 hours
- b Based on the three largest air carrier airports
- c Based on the rest of the 10 largest air carrier airports
- d Based on other airports in the 20 largest air carrier airports

e Based on selected medium hub air carrier airports
f Based on selected large general aviation airports
g Based on selected small hub air carrier airports
h Based on selected medium sized general aviation airports
i Based on selected small general aviation airports

When possible, it is desirable to use site specific hourly demand distributions. Data on the hourly distribution of demand can usually be obtained by contacting the tower chief at the respective airport.

e. Hourly Distribution of Demand by Weather Condition. The On-line Annual Delay Model considers three weather conditions; i.e., VFR, IFR and PVC. These weather conditions have the same meanings as used in Chapter 3.

The On-line Annual Delay Model will allow the level of operations in IFR and PVC to be set equal to some percent of the level of operations in VFR. This accounts for the general phenomena that demand in IFR is lower than in VFR because uninstrumented aircraft are prevented from using the runways, and demand in PVC is much lower than VFR because of poor operating conditions.

f. Runway Use Configuration Utilization Percent by Weather. The On-line Annual Delay Model requires the percent of the time that each runway use configuration is used. This is done for all VFR, all IFR and all PVC runway use configurations. The model assumes that the capacity of each runway use configuration is constant across the day. Therefore, it is advisable not to enter data for runway use configurations that are only used during very low demand time periods (e.g., 10:00 p.m. to 5:00 a.m.).

It is recommended that only runway use configurations that occur for at least 2% of the VFR, or IFR or PVC days be considered in the annual delay analysis.

g. Demand Profile Factor. The demand profile factor is defined as the percent of the hourly demand that occurs in the peak 15 minutes. To allow for the variation of demand profile factor from hour to hour, input the average demand profile factor for the busy hours of the day.

h. Touch-and-Go Operations. Touch-and-go operations do not normally occur during busy hours at commercial airports. Therefore, touch-and-go operations should be excluded from the annual operations when determining annual delay for commercial airports. If touch-and-go operations are included in the annual operations for a general aviation airport, the hourly

capacities should be based on the same percent touch-and-go. The Annual Delay Model treats touch-ang-go operations as one arrival and one departure. If a runway use configuration consists of one runway used exclusively for touch-and-go operations and one runway for arrival and departure operations, the annual delay analysis should be done separately for each runway.

6.3 Data Requests

The following defines the data requests and acceptable inputs for the On-line Annual Delay Model:

ENTER ANNUAL DEMAND

This data request is typed after the program identification code is entered (e.g., EX AND). Enter the total number of arrivals plus departures for the year. A comma is not used for values over 1000 (e.g., enter 225000 instead of 225,000).

ENTER FOR EVERY MONTH
PERCENT OF ANNUAL DEMAND
PERCENT OF MONTH WHICH IS VFR, IFR, AND PVC
JANUARY

Four numbers should be entered on the line immediately after the word January (e.g., 7.6 96 3 1). A space should separate each number. The first number is January's percent of annual operations and the second, third, and fourth numbers are the percent of January days which are VFR, IFR, and PVC respectively. The second, third, and fourth numbers must sum to 100. The terminal will request data for FEBRUARY as soon as valid input data is provided for January. This process is repeated until the data have been entered for all 12 months. The terminal will repeat the entire data request if the monthly percentages of annual operations do not sum to 100.

As an alternative to entering the annual operations and weather distributions, the user can enter an annual operations distribution letter and annual weather distribution letter for the JANUARY input. The On-line Annual Delay Model will then proceed to the next question.

ENTER IFR AND PVC OPERATIONS AS A PERCENT OF VFR OPERATIONS

This data request requires two numbers (each between 0 and 100) be entered with a space between them. The first number is: 100 times the operations on an average IFR day divided by operations on an average VFR day. The second number is: 100 times the operations on an average PVC day divided by operations on an average VFR day.

ENTER DAILY OPERATIONS AS A PERCENT OF WEEKLY
OPERATIONS MONDAY

This data request requires one number (between 0 and 100) be entered. The terminal will type TUESDAY after a number is entered for Monday; another number should be entered on this line. This process is repeated until a number has been entered for each day of the week. This entire data request is repeated if the seven numbers do not sum to 100.

As an alternative to entering the daily demand distribution, the user can enter the daily demend distribution letter for the MONDAY input. The On-line Annual Delay Model will then proceed to the next question.

ENTER HOURLY OPERATIONS AS A PERCENT OF DAILY
OPERATIONS
0-1

This data request requires one number (between 0 and 100) be entered. The terminal will automatically type "1-2" as soon as data has been entered for the hour "0-1." This process is repeated through the hour "23-24." The terminal will repeat the entire data request if the 24 numbers do not sum to 100.

As an alternative to entering the hourly demand distribution, the user can enter the hourly demand distribution letter for the 0-1 input. The On-line Annual Delay Model will then proceed to the next question.

ENTER DEMAND PROFILE FACTOR

This data request requires one number. Acceptable values of the demand profile factor are 25, 30, 35, 40, 45 and 50.

ENTER THE FOLLOWING FOR EVERY VFR RUNWAY USAGE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX
INDEX, HOURLY RUNWAY CAPACITY, AND PERCENT OF THE
VFR DAYS USED

This data request requires one or more lines of data where each line of data is for a specific VFR runway use configuration. The first number per line is an integer 1 through 122 which defines the runway use configuration as illustrated in Figure 6-1. (Figure 2-2 in the computer question refers to Figure 2-2 in reference b.) The second number is the mix index; i.e., % C aircraft + 3 % D aircraft. The third number is the hourly runway capacity as computed from Chapter 2 or 3. The fourth number per line is the percent of the VFR days that the runway use configuration is used. The percent of the VFR days used summed over all VFR runway use configurations must sum to 100.

Any number of lines of data can be entered. Every line of data has four numbers. The first number is an integer 1 through

122, the second number is an integer 0 through 300, the third number is a positive number less than 500, and the fourth number is between 1 and 100.

ENTER THE FOLLOWING FOR EVERY IFR RUNWAY USAGE: RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX, HOURLY RUNWAY CAPACITY, AND PERCENT OF THE IFR DAYS USED

This data request is the IFR version of the preceeding data request. The input format is identical to that for VFR runway usages. The computer will go to the next data request when the "percent of the IFR days used" sums to 100.

ENTER THE FOLLOWING FOR EVERY PVC RUNWAY USAGE: RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX, HOURLY RUNWAY CAPACITY, AND PERCENT OF THE PVC DAYS USED

This data request is the PVC version of the previous two data requests. It is necessary to enter data for this data request even if PVC weather does not occur (e.g., enter 1 1 1 100).

6.4 Output

Immediately after the PVC runway use configuration data is entered, the On-line Annual Delay Model will type an input summary. The input summary defines the data used to determine annual delay; this includes the actual data if built-in data is used for: monthly percent of annual operations and monthly weather distribution, daily percent of the weekly operations, the hourly percent of the daily operations. The input summary does not contain any error messages and can serve as a permanent record of inputs used for the calculation.

The output of the On-line Annual Delay Model is typed after the input summary. The output includes:

a. the total annual runway delay (in hours and minutes)

b. the average runway delay per operation (in minutes)

c. the distribution of delay per operation

After the output is printed, it is possible to do parametric variations on annual opeations. The teletype will print: DO YOU WISH TO DETERMINE ANNUAL DELAY FOR ANOTHER ANNUAL DEMAND? If a "y" response is given, the terminal will make the data request ENTER ANNUAL DEMAND and calculate annual delay assuming all other inputs are identical. If any response other than "y" is given, the terminal will type the following data request:

DO YOU WISH TO PERFORM ANOTHER CALCULATION?

A "y" response to this data request will repeat the entire series of data requests for the On-line Annual Delay Model. Any other response will automatically terminate use of the On-line Annual Delay Model.

6.5 Optional uses of On-line Annual Delay Model

The On-line Annual Delay Model can be used with built-in demand distribution data to calculate:

The delay for an hour
The delay for a series of hours
The delay for a day
The delay for a week
The delay for a month
Measures of annual capacity

The following defines procedures for determining these outputs:

a. Hourly Delay. The hourly delay for a given demand per hour can be determined by:

1) Entering annual operations equal to the hourly demand x 5840. (NOTE: The On-line Annual Delay Model requires an annual demand equal to 5840 times hourly demand and the use of hourly demand distribution letter a in order to compute average delay per operation for the desired hourly demand.)

2) Entering a for the JANUARY annual demand distribution data.

3) Entering 100 100 for IFR and PVC operations as a percent of VFR.

4) Entering a for the MONDAY daily demand distribution data.

5) Entering a for the 0-1 hourly demand distribution data.

6) Entering 100 for the percent of VFR days used in the runway use configuration capacity data. Enter the appropriate runway use diagram number, mix index and hourly runway capacity.

7) Entering the same capacity and percent utilization data for IFR and PVC conditions as was used for VFR conditions.

The model output of average delay per operation is the average delay per operation for the hour under consideration.

b. Delay for a Series of Consecutive Hours. The delay for 2 or more consecutive hours up to 24 hours can be determined by:

1) Entering annual operations equal to the total hourly demand for the series of hours x 365.

2) Entering a for the January annual demand distribution data.

3) Entering 100 100 for IFR and PVC operations as a percent of VFR.

4) Entering a for the Monday daily demand distribution data.

5) Entering the hourly demand percents based on the total demand for the series of hours under consideration. Enter zero for all other hours. The entered values must sum to 100.0.

6) Entering 100 for the percent of VFR days used in the runway use configuration capacity data. Enter the appropriate runway use diagram number, mix index and hourly runway capacity.

7) Entering the same capacity and percent utilization data for IFR and PVC conditions as was used for VFR conditions.

The model output of average delay per operation is the average delay per operation over the time span considered.

c. Daily Delay. The average delay per operation for a day can be determined by following the procedure defined by b. above using an hourly demand distribution for the complete 24-hour period.

d. Weekly Delay. The average delay per operation for a particular week can be determined by computing the daily delay for the conditions specific to each day (or group of days) of the week.

e. Monthly Delay. The average delay per operation for a particular month can be determined by computing the daily delay for the conditions specific to each day (or group of days) of the month.

f. Measures of Annual Capacity. The On-line Annual Delay Model can be used to determine a level of service of annual capacity based on:

1) The average delay per operation produced by a given number of annual operations.

2) The percent of annual operations having delays in excess of some selected delay per operation.

3) Some combination of the above.

The procedure is to operate the model at different values of annual operations but keeping all other inputs fixed. This can easily be done by entering "y" to the question: DO YOU WISH TO DETERMINE ANNUAL DELAY FOR ANOTHER ANNUAL DEMAND? The model output can then be analyzed to determine annual capacity based on user specified level of service considerations.

6.6 Examples

The following examples illustrate the use of On-line Annual Delay Model Version 1. Common data for all examples are:

Percent Arrival = 50
Percent Touch-and-Go = 0
Mix index = 120; i.e., 0%A, 10%B, 60%C, 30%D
Demand Profile Factor = 40

Geometry	Diagram Number	Capacity VFR	Capacity IFR	Percent Utilization VFR	Percent Utilization IFR
Single Runway	1	54	52	10	30
Parallel Runway	2	77	60	50	45
Intersecting Runway	43	75	59	40	25

Example 1

Compute the total annual delay and average annual delay per operation for the following conditions:

Annual demand = 200,000 and 300,000 operations/year	
Annual demand distribution	b
Annual weather distribution	a
Daily demand distribution	d
Hourly demand distribution	b
IFR demand = 90% of VFR demand	

The computer dialogue for this problem is shown in Figure 6-1. The annual delay is:

Annual Demand	Annual Delay
200000	1396 hours
300000	9697 hours

NOTE: The *** in the Input Summary for VFR weather means that VFR weather conditions occur 100 percent of the month.

Example 2

Analyze annual delay for the following conditions:

Annual demand = 250,000 operations
IFR demand = 100% of VFR demand

Annual Demand Distribution

January	9.1	July	7.7
February	9.4	August	7.4
March	9.4	September	7.4
April	9.4	October	8.0
May	8.0	November	8.1
June	7.4	December	8.7

Annual Weather Distribution

	VFR	IFR	PVC		VFR	IFR	PVC
January	91	9	0	July	84	16	0
February	90	10	0	August	87	13	0
March	91	9	0	September	86	14	0
April	87	13	0	October	86	14	0
May	90	10	0	November	87	13	0
June	89	11	0	December	89	11	0

Daily Demand Distribution

Monday	14	Friday	15
Tuesday	16	Saturday	13
Wednesday	14	Sunday	13
Thursday	15		

Hourly Demand Distribution

0-1	2.27	6-7	1.53	12-13	5.28	18-19	6.51
1-2	1.81	7-8	4.11	13-14	5.56	19-20	6.69
2-3	1.19	8-9	6.47	14-15	5.16	20-21	5.94
3-4	0.92	9-10	6.09	15-16	5.18	21-22	4.28
4-5	0.55	10-11	4.69	16-17	6.23	22-23	3.20
5-6	0.74	11-12	5.73	17-18	6.93	23-24	2.94

The computer dialogue for this problem is shown in Figure 6-2. The total annual delay is 5019 hours. The average delay per operation is 1.2 minutes.

Example 3

For the conditions given in Example 1, compute the annual demand that produces an average delay of 1.0 minutes per operation.

The following additional runs were made for the conditions given in example 1. The results were:

Annual Demand	Average Annual Delay
200,000 operations	0.42 minutes
250,000 operations	0.73 minutes
265,000 operations	0.92 minutes
270,000 operations	1.07 minutes
275,000 operations	1.22 minutes
300,000 operations	1.94 minutes

From these results, an annual demand of approximately 267,500 operations will produce an average annual delay per operation of 1.0 minutes.

Example 4

For the conditions given in Example 1, compute the average delay per operation in VFR for the single runway for the following 4 consecutive hours.

Hour	Demand	Demand Distribution
15-16	40	22%
16-17	50	28%
17-18	60	33%
18-19	30	17%

The computer dialogue for this problem is shown in Figure 6-3. The annual demand equals 180 x 365 = 65,700 operations. The average delay is 1.34 minutes per operation.

COMPUTER DIALOGUE FOR EXAMPLE 1
FIGURE C-1

```
ex and

                    *** COMPUTERIZED ANNUAL DELAY ***
                          VERSION 1 (MAY 1976)

ENTER ANNUAL DEMAND
200000

ENTER FOR EVERY MONTH:
  PERCENT OF ANNUAL DEMAND
  PERCENT OF MONTH WHICH IS VFR, IFR,
  AND PVC

JANUARY
b,a

ENTER IFR AND PVC OPERATIONS AS A
PERCENT OF VFR OPERATIONS
90,90

ENTER DAILY OPERATIONS AS A
PERCENT OF WEEKLY OPERATIONS

MONDAY
d

ENTER HOURLY OPERATIONS AS A
PERCENT OF DAILY OPERATIONS

 0- 1
b

ENTER DEMAND PROFILE FACTOR
40

ENTER THE FOLLOWING FOR EVERY VFR RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF VFR DAYS USED
1-
1,120,54,10
2-
2,120,77,50
3-
43,120,75,40

ENTER THE FOLLOWING FOR EVERY IFR RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF IFR DAYS USED
1-
1,120,52,30
2-
2,120,60,45
3-
43,120,59,25

ENTER THE FOLLOWING FOR EVERY PVC RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF PVC DAYS USED
1-
```

1,120,50,100

FIGURE 6-1 (Cont.)

*** INPUT SUMMARY ***
COMPUTERIZED ANNUAL DELAY
VERSION 1 (MAY 1976)

ANNUAL OPERATIONS 200000

MONTH	% OF ANNUAL OPERATIONS	MONTHLY WEATHER % VFR	IFR	PVC
JAN	8.0	98.	2.	0.
FEB	7.6	98.	2.	0.
MAR	8.1	98.	2.	0.
APR	8.0	99.	1.	0.
MAY	8.2	99.	1.	0.
JUN	8.7	***	0.	0.
JUL	8.8	***	0.	0.
AUG	8.9	***	0.	0.
SEP	8.7	***	0.	0.
OCT	8.7	99.	1.	0.
NOV	8.2	98.	2.	0.
DEC	8.1	99.	1.	0.

DAILY OPERATIONS (IFR DAY)/(VFR DAY) = 90.0%
DAILY OPERATIONS (PVC DAY)/(VFR DAY) = 90.0%

DAILY OPERATIONS AS A PERCENT OF WEEKLY OPN.

MON	TUES	WED	THU	FRI	SAT	SUN
15.0	12.0	12.0	13.0	18.0	14.0	16.0

HOURLY OPNS AS A PERCENT OF DAILY OPNS

0- 1	2.3	6- 7	1.5	12-13	5.3	18-19	6.5
1- 2	1.8	7- 8	4.1	13-14	5.6	19-20	6.7
2- 3	1.2	8- 9	6.5	14-15	5.2	20-21	5.9
3- 4	0.9	9-10	6.1	15-16	5.2	21-22	4.3
4- 5	0.6	10-11	4.7	16-17	6.2	22-23	3.2
5- 6	0.7	11-12	5.7	17-18	6.9	23-24	2.9

DEMAND PROFILE FACTOR = 40

VFR RUNWAY USAGES

FIG NO.	MIX INDEX	HOURLY CAPACITY	% DAYS USED
1	120	54.	10.
2	120	77.	50.
43	120	75.	40.

IFR RUNWAY USAGES

1	120	52.	30.
2	120	60.	45.
43	120	59.	25.

```
PVC RUNWAY USAGES

  1      120              50.        100.
```

FIGURE 6-1 (Cont.)

```
* * * * * * * * * * * * * * * * * * * * *

**************************************************************

                    ANNUAL SUMMARY

          AVERAGE DELAY              DISTRIBUTION
            (MINUTES)                  PERCENT
       AT LEAST      LESS THAN        OCCURRENCE

         0.0            0.2             12.585
         0.2            0.4             36.868
         0.4            0.6             32.344
         0.6            0.8             12.589
         0.8            1.0              4.049
         1.0            1.2              0.203
         1.2            1.4              0.005
         1.4            1.6              0.362
         1.6            1.8              0.339
         1.8            2.0              0.191
         2.0            3.0              0.408
         3.0            4.0              0.057

          MEAN OF AVERAGE DELAY =        0.42
               STANDARD DEVIATION  =     0.19

**************************************************************

       ANNUAL DELAY = 1396.229  HOURS
      ANNUAL DEMAND =   200000  OPERATIONS
      AVERAGE DELAY =     0.42  MINUTES-AIRCRAFT


DO YOU WISH TO DETERMINE ANNUAL DELAY
FOR ANOTHER ANNUAL DEMAND?
Y
ENTER ANNUAL DEMAND
300000


          *** INPUT SUMMARY ***
        COMPUTERIZED ANNUAL DELAY
          VERSION 1 (MAY 1976)

ANNUAL OPERATIONS   300000
```

MONTH	% OF ANNUAL OPERATIONS	MONTHLY WEATHER % VFR	IFR	PVC
JAN	8.0	98.	2.	0.
FEB	7.6	98.	2.	0.
MAR	8.1	98.	2.	0.
APR	8.0	99.	1.	0.
MAY	8.2	99.	1.	0.
JUN	8.7	***	0.	0.
JUL	8.8	***	0.	0.
AUG	8.9	***	0.	0.
SEP	8.7	***	0.	0.
OCT	8.7	99.	1.	0.
NOV	8.2	98.	2.	0.
DEC	8.1	99.	1.	0.

FIGURE 6-1 (Cont.)

DAILY OPERATIONS (IFR DAY)/(VFR DAY) = 90.0%
DAILY OPERATIONS (PVC DAY)/(VFR DAY) = 90.0%

DAILY OPERATIONS AS A PERCENT OF WEEKLY OPN.

MON	TUES	WED	THU	FRI	SAT	SUN
15.0	12.0	12.0	13.0	18.0	14.0	16.0

HOURLY OPNS AS A PERCENT OF DAILY OPNS

0- 1	2.3	6- 7	1.5	12-13	5.3	18-19	6.5
1- 2	1.8	7- 8	4.1	13-14	5.6	19-20	6.7
2- 3	1.2	8- 9	6.5	14-15	5.2	20-21	5.9
3- 4	0.9	9-10	6.1	15-16	5.2	21-22	4.3
4- 5	0.6	10-11	4.7	16-17	6.2	22-23	3.2
5- 6	0.7	11-12	5.7	17-18	6.9	23-24	2.9

DEMAND PROFILE FACTOR = 40

VFR RUNWAY USAGES

FIG NO.	MIX INDEX	HOURLY CAPACITY	% DAYS USED
1	120	54.	10.
2	120	77.	50.
43	120	75.	40.

IFR RUNWAY USAGES

1	120	52.	30.
2	120	60.	45.
43	120	59.	25.

PVC RUNWAY USAGES

1	120	50.	100.

*

****

ANNUAL SUMMARY

AVERAGE DELAY (MINUTES) AT LEAST	LESS THAN	DISTRIBUTION PERCENT OCCURRENCE
0.0	0.2	7.154
0.2	0.4	8.939
0.4	0.6	12.317
0.6	0.8	15.616
0.8	1.0	15.077
1.0	1.2	9.168
1.2	1.4	6.597
1.4	1.6	4.772
1.6	1.8	3.386
1.8	2.0	2.332
2.0	3.0	7.152
3.0	4.0	2.280
4.0	5.0	0.558
5.0	6.0	0.282
6.0	7.0	0.159
7.0	8.0	0.307
8.0	9.0	0.113
9.0	10.0	0.128
10.0	11.0	0.044
11.0	12.0	0.202
12.0	13.0	0.120
13.0	14.0	0.327
14.0	15.0	0.057
15.0	16.0	0.164
16.0	17.0	0.060
17.0	18.0	0.004
20.0	21.0	0.062
22.0	23.0	0.068
24.0	25.0	0.070
25.0	26.0	0.138
26.0	27.0	0.070
47.0	48.0	0.298
48.0	49.0	0.151
49.0	50.0	0.149
50.0	51.0	0.467
52.0	53.0	0.176
53.0	54.0	0.190
54.0	55.0	0.355

FIGURE 6-1 (Cont.)

MEAN OF AVERAGE DELAY = 1.94
STANDARD DEVIATION = 2.50

****

ANNUAL DELAY = 9696.730 HOURS
ANNUAL DEMAND = 300000 OPERATIONS
AVERAGE DELAY = 1.94 MINUTES-AIRCRAFT

DO YOU WISH TO DETERMINE ANNUAL DELAY
FOR ANOTHER ANNUAL DEMAND?

COMPUTER DIALOGUE FOR EXAMPLE 2
FIGURE 6-2

```
ex and

          *** COMPUTERIZED ANNUAL DELAY ***
                VERSION 1 (MAY 1976)

ENTER ANNUAL DEMAND
250000

ENTER FOR EVERY MONTH:
  PERCENT OF ANNUAL DEMAND
  PERCENT OF MONTH WHICH IS VFR, IFR,
  AND PVC

JANUARY
9.1 91 9 0

FEBRUARY
9.4 90 10 0

MARCH
9.4 91 9 0

APRIL
9.4 87 13 0

MAY
8.0 90 10 0

JUNE
8990 10 0

FIRST DATA ITEM IS NOT A NUMBER OR LETTER A TO G,
INPUT DATA AGAIN

JUNE
7.4 89 11 0

JULY
7.7 84 16 0

AUGUST
7.4 87 13 0

SEPTEMBER
7.4 86 14 0

OCTOBER
8.0 86 14 0

NOVEMBER
8.1 87 13 0

DECEMBER
8.7 89 11 0

ENTER IFR AND PVC OPERATIONS AS A
PERCENT OF VFR OPERATIONS
100 100
```

ENTER DAILY OPERATIONS AS A
PERCENT OF WEEKLY OPERATIONS

MONDAY
14

TUESDAY
16

WEDNESDAY
14

FIGURE 6-2 (Cont.)

THURSDAY
15

FRIDAY
15

SATURDAY
13

SUNDAY
13

ENTER HOURLY OPERATIONS AS A
PERCENT OF DAILY OPERATIONS

0- 1
2.27

1- 2
1.1a

DATA ITEM IS NOT A NUMBER OR LETTER A TO I, INPUT DATA AGAIN

1- 2
1.81

2- 3
1.19

3- 4
.92

4- 5
.55

5- 6
.74

6- 7
1.53

7- 8
4.11

8- 9
6.47

9-10
6.09

10-11
4.69

```
11-12
5.74a

DATA ITEM IS NOT A NUMBER OR LETTER A TO I, INPUT DATA AGAIN

11-12
5.73

12-13
5.28

13-14
5.56

14-15
5.16

15-16
5.18

16-17
6.23

17-18
6.93

18-19
6.51

19-20
6.69

20-21
5.94

21-22
4.28

22-23
3.2

23-24
2.94

ENTER DEMAND PROFILE FACTOR
40

ENTER THE FOLLOWING FOR EVERY VFR RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF VFR DAYS USED
1-
1 120 54 10
2-
2 120 77 50
3-
43 120 75 40

ENTER THE FOLLOWING FOR EVERY IFR RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF IFR DAYS USED
1-
1 120 52 30
2-
2 120 60 45
3-
```

FIGURE 6-2 (Cont.)

43 120 40 25

ENTER THE FOLLOWING FOR EVERY PVC RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF PVC DAYS USED
1-
1,50,50,100

*** INPUT SUMMARY ***
COMPUTERIZED ANNUAL DELAY
VERSION 1 (MAY 1976)

FIGURE 6-2 (Cont.)

ANNUAL OPERATIONS 250000

MONTH	% OF ANNUAL OPERATIONS	MONTHLY WEATHER % VFR	IFR	PVC
JAN	9.1	91.	9.	0.
FEB	9.4	90.	10.	0.
MAR	9.4	91.	9.	0.
APR	9.4	87.	13.	0.
MAY	8.0	90.	10.	0.
JUN	7.4	89.	11.	0.
JUL	7.7	84.	16.	0.
AUG	7.4	87.	13.	0.
SEP	7.4	86.	14.	0.
OCT	8.0	86.	14.	0.
NOV	8.1	87.	13.	0.
DEC	8.7	89.	11.	0.

DAILY OPERATIONS (IFR DAY)/(VFR DAY) =100.0%
DAILY OPERATIONS (PVC DAY)/(VFR DAY) =100.0%

DAILY OPERATIONS AS A PERCENT OF WEEKLY OPN.

MON	TUES	WED	THU	FRI	SAT	SUN
14.0	16.0	14.0	15.0	15.0	13.0	13.0

HOURLY OPNS AS A PERCENT OF DAILY OPNS

0- 1	2.3	6- 7	1.5	12-13	5.3	18-19	6.5
1- 2	1.8	7- 8	4.1	13-14	5.6	19-20	6.7
2- 3	1.2	8- 9	6.5	14-15	5.2	20-21	5.9
3- 4	0.9	9-10	6.1	15-16	5.2	21-22	4.3
4- 5	0.6	10-11	4.7	16-17	6.2	22-23	3.2
5- 6	0.7	11-12	5.7	17-18	6.9	23-24	2.9

DEMAND PROFILE FACTOR = 40

VFR RUNWAY USAGES

FIG NO.	MIX INDEX	HOURLY CAPACITY	% DAYS USED
1	120	54.	10.
2	120	77.	50.
43	120	75.	40.

IFR RUNWAY USAGES

1	120	52.	30.
2	120	60.	45.
43	120	40.	25.

FIGURE 6-2 (Cont.)

PVC RUNWAY USAGES

1	50	50.	100.

****

ANNUAL SUMMARY

AVERAGE DELAY (MINUTES) AT LEAST	LESS THAN	DISTRIBUTION PERCENT OCCURRENCE
0.0	0.2	8.778
0.2	0.4	14.154
0.4	0.6	24.796
0.6	0.8	20.707
0.8	1.0	13.139
1.0	1.2	5.639
1.2	1.4	2.105
1.4	1.6	1.751
1.6	1.8	1.354
1.8	2.0	1.034
2.0	3.0	2.420
3.0	4.0	1.037
4.0	5.0	0.438
5.0	6.0	0.417
6.0	7.0	0.153
7.0	8.0	0.360
8.0	9.0	0.148
9.0	10.0	0.095
10.0	11.0	0.109
11.0	12.0	0.195
12.0	13.0	0.069
13.0	14.0	0.086
18.0	19.0	0.026
19.0	20.0	0.073
45.0	46.0	0.066
46.0	47.0	0.055
47.0	48.0	0.217
48.0	49.0	0.122
51.0	52.0	0.195
54.0	55.0	0.036
56.0	57.0	0.131
63.0	64.0	0.044

MEAN OF AVERAGE DELAY = 1.20
STANDARD DEVIATION = 1.74

****

ANNUAL DELAY = 5019.008 HOURS
ANNUAL DEMAND = 250000 OPERATIONS
AVERAGE DELAY = 1.20 MINUTES-AIRCRAFT

DO YOU WISH TO DETERMINE ANNUAL DELAY
FOR ANOTHER ANNUAL DEMAND?
no

DO YOU WISH TO PERFORM ANOTHER CALCULATION?
no

FIGURE 6-2 (Cont.)

COMPUTER DIALOGUE FOR EXAMPLE 4
FIGURE 6-3

```
ex and

          *** COMPUTERIZED ANNUAL DELAY ***
                VERSION 1 (MAY 1976)

ENTER ANNUAL DEMAND
65700

ENTER FOR EVERY MONTH:
  PERCENT OF ANNUAL DEMAND
  PERCENT OF MONTH WHICH IS VFR, IFR,
  AND PVC

JANUARY
a,a

ENTER IFR AND PVC OPERATIONS AS A
PERCENT OF VFR OPERATIONS
100,100

ENTER DAILY OPERATIONS AS A
PERCENT OF WEEKLY OPERATIONS

MONDAY
a

ENTER HOURLY OPERATIONS AS A
PERCENT OF DAILY OPERATIONS

 0- 1
0

 1- 2
0

 2- 3
0

 3- 4
0

 4- 5
0

 5- 6
0

 6- 7
0

 7- 8
0

 8- 9
0

 9-10
0
```

10-11
0

11-12
0

12-13
0

13-14
0

14-15
0

FIGURE 6-3 (Cont.)

15-16
22

16-17
28

17-18
33

18-19
17

19-20
0

20-21
0

21-22
0

22-23
0

23-24
0

ENTER DEMAND PROFILE FACTOR
40

ENTER THE FOLLOWING FOR EVERY VFR RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF VFR DAYS USED
1-
1,120,54,10
2-
2,120,77,50
3-
43,120,75,40

ENTER THE FOLLOWING FOR EVERY IFR RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF IFR DAYS USED
1-
1,120,54,10
2-
2,120,77,50
3-
43,120,75,40

ENTER THE FOLLOWING FOR EVERY **PVC RUNWAY** USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF PVC DAYS USED
1-
1,120,54,10
2-
2,120,77,50
3-
43,120,75,40

FIGURE 6-3 (Cont.)

*** INPUT SUMMARY ***
COMPUTERIZED ANNUAL DELAY
VERSION 1 (MAY 1976)

ANNUAL OPERATIONS 65700

MONTH	% OF ANNUAL OPERATIONS	MONTHLY WEATHER % VFR	IFR	PVC
JAN	8.3	98.	2.	0.
FEB	8.3	98.	2.	0.
MAR	8.3	98.	2.	0.
APR	8.3	99.	1.	0.
MAY	8.3	99.	1.	0.
JUN	8.4	***	0.	0.
JUL	8.4	***	0.	0.
AUG	8.4	***	0.	0.
SEP	8.4	***	0.	0.
OCT	8.3	99.	1.	0.
NOV	8.3	98.	2.	0.
DEC	8.3	99.	1.	0.

DAILY OPERATIONS (IFR DAY)/(VFR DAY) =100.0%
DAILY OPERATIONS (PVC DAY)/(VFR DAY) =100.0%

DAILY OPERATIONS AS A PERCENT OF WEEKLY OPN.

MON	TUES	WED	THU	FRI	SAT	SUN
14.2	14.3	14.3	14.3	14.3	14.3	14.3

HOURLY OPNS AS A PERCENT OF DAILY OPNS

0- 1	0.0	6- 7	0.0	12-13	0.0	18-19	17.0
1- 2	0.0	7- 8	0.0	13-14	0.0	19-20	0.0
2- 3	0.0	8- 9	0.0	14-15	0.0	20-21	0.0
3- 4	0.0	9-10	0.0	15-16	22.0	21-22	0.0
4- 5	0.0	10-11	0.0	16-17	28.0	22-23	0.0
5- 6	0.0	11-12	0.0	17-18	33.0	23-24	0.0

DEMAND PROFILE FACTOR = 40

VFR RUNWAY USAGES

FIG NO.	MIX INDEX	HOURLY CAPACITY	% DAYS USED
1	120	54.	10.
2	120	77.	50.
43	120	75.	40.

IFR RUNWAY USAGES

1	120	54.	10.
2	120	77.	50.
43	120	75.	40.

PVC RUNWAY USAGES

1	120	54.	10.
2	120	77.	50.
43	120	75.	40.

FIGURE 6-3 (Cont.)

*

****

ANNUAL SUMMARY

AVERAGE DELAY (MINUTES) AT LEAST	LESS THAN	DISTRIBUTION PERCENT OCCURRENCE
0.2	0.4	11.797
0.4	0.6	17.310
0.6	0.8	5.993
0.8	1.0	10.557
1.0	1.2	6.655
1.2	1.4	8.064
1.4	1.6	13.637
1.6	1.8	6.520
1.8	2.0	1.477
2.0	3.0	2.374
3.0	4.0	1.357
4.0	5.0	0.007
6.0	7.0	4.551
7.0	8.0	0.014
8.0	9.0	0.686

MEAN OF AVERAGE DELAY = 1.34
STANDARD DEVIATION = 0.85

****

```
ANNUAL DELAY = 1468.814  HOURS
ANNUAL DEMAND =   65700  OPERATIONS
AVERAGE DELAY =    1.34  MINUTES-AIRCRAFT


DO YOU WISH TO DETERMINE ANNUAL DELAY
FOR ANOTHER ANNUAL DEMAND?
no

DO YOU WISH TO PERFORM ANOTHER CALCULATION?
no
```

FIGURE 6-3 (Cont.)

CHAPTER 7 - ON-LINE ANNUAL SERVICE VOLUME MODEL VERSION 1 - ANNUAL SERVICE VOLUME

7.1 Introduction

The On-line Annual Service Volume Model is a tutorial program for calculating annual service volume. It is similar in operation to the On-line Runway Capacity Model discussed in Chapter 3.

Annual service volume is a measure of the annual capacity of an airport. Annual service volume is not a saturation capacity but rather a level of service capacity. In developing the Annual Service Volume Model contained in this chapter, the following level of service criteria were used:

a. As annual demand approaches annual service volume, delay to aircraft starts to increase rapidly.

b. When annual demand equals annual service volume, a reasonable level of service exists for much of the year.

c. When annual demand is 20 percent more than annual service volume, the airport will experience severe congestion.

Annual service volume is useful as a guide to determine the need for more specific analysis, and as a preliminary planning analysis that may be useful in the National Aviation System Plan (NASP) or state and regional system plans. It is not meant as a replacement for detailed hourly evaluation of complex airport operations, and should not be the sole justification for airfield improvements, entrance into the Airport Development Aid Program (ADAP) or other allocations of financial resources.

A list of computer services (or timesharing companies) offering the program can be obtained from:

Chief, Airport Design Branch, ARD-410
2100 Second Street, S.W.
Washington, D.C. 20590

(202) 426-3685

7.2 Model Logic

Annual service volume is computed by the following deterministic equation:

$$\text{Annual Service Volume} = \frac{Cw \times ATD \times 100}{DTD \times H}$$

where

CW is the weighted hourly capacity, computed by

$$Cw = \frac{\sum_{i=1}^{N} Ci\ Wi\ Pi}{\sum_{i=1}^{N} Wi\ Pi}$$

where Pi is the proportion of the year with capacity Ci, and Wi is the weight to be applied to Ci values. Wi values are determined from the following table:

Percent of Maximum Capacity	Weight Wi VFR 0-300	IFR Mix Index 0-20	21-50	51-300
90-100	1	1	1	1
81-90	5	1	3	5
66-80	15	2	8	15
51-65	20	2	12	20
0-50	25	4	16	25

H is the percent of the daily demand that occurs in the peak hour.

ATD is the annual traffic demand.

DTD is the daily traffic demand for the average day of the peak month.

The factor 100/H extends an hourly capacity to a daily capacity. The factors ATD/DTD extends the daily capacity to an annual capacity.

The weighting factors Wi were established emperically to give annual delays per aircraft of 2 to 4 minutes. The mix index used in association with the Wi factors is %C + 3%D, where C & D aircraft are defined in Figure 1-1. The Wi factors are related to the percent of maximum capacity to account for the disproportionately large impact on delay of a low hourly capacity used a small percent of the time. The same Wi factors are used for IFR and PVC.

7.3 Input Format

The following is a detailed description of the data requests and the acceptable inputs for the On-line Annual Service Volume Model:

ENTER THE NUMBER OF RUNWAY USE CONFIGURATIONS TO BE CONSIDERED.

This data request is typed after the program identification code is entered (e.g., EXECUTE ASV.RDL). Allowable inputs are 1 through 25.

FOR RUNWAY USE CONFIGURATION NUMBER 1

HC =
% =
W =
MI =

HC is the hourly capacity of the runway use configuration.
% is the utilization percent of the runway use configuration.
W is the weather code for the runway capacity.
MI is the mix index associated with the runway use configuration.

Allowable inputs for HC are 0 through 400. If HC is negative, the run will be aborted.

Allowable inputs for % are 1 through 100. If % is negative, the run will be aborted.

Allowable inputs for W are:

1 for VFR
2 for IFR
3 for PVC

Allowable inputs for MI are 0 through 180.

This series of questions will be repeated for each runway use configuration. If the summation of % over all runway use configurations does not equal 100, the user will be requested to reenter % for each runway use configuration.

ENTER THE PERCENT OF THE DAILY DEMAND THAT OCCURS IN THE PEAK HOUR.

Allowable inputs are 4 through 20.

ENTER THE ANNUAL TRAFFIC DEMAND.

Allowable inputs are 1000 through 1,000,000.

ENTER THE DAILY TRAFFIC DEMAND FOR THE AVERAGE DAY OF THE PEAK MONTH.

Allowable inputs are 0 through 4000.

7.4 Input Considerations

The following factors should be considered in determining annual service volume:

a. Operating Period. The percent utilization for each runway use configuration should be based on conditions that occur during potentially busy hours. In general, late night and early morning hours have very low demands and thus tend to employ runway use configurations that have lower capacities. Every effort should be made to eliminate these low runway use configurations from the analysis. For example, if the VFR capacity between 7 a.m. and 10 p.m. was 140 operations per hour in VFR and 110 operations in IFR, and the capacity between 10 p.m. and 7 a.m. was 70 operations per hour because the traffic demand did not require the use of all runways, the annual service volume should be based on the percent occurrance of the VFR and IFR capacities between 7 a.m. and 10 p.m.

b. Maintenance. In determining the percent utilization of each runway use configuration consideration should be given to the fact that runways will be down periodically for maintenance. This will tend to decrease the percent utilization of high capacity runway use configurations and increase the percent utilization of low capacity runways.

c. Daily and Annual Demand. To compute annual service volume requires information on annual traffic demand (ATD) and the demand for the average day of the peak month (DTD). If these values are not available from records, they can be arrived at by setting the ratio (R) of ATD/DTD equal to the equivalent number of busy days during the year. Airports with a high percent of commerical aircraft tend to have a ratio of around 340. Airports with a high percent of general aviation aircraft tend to have a ratio of around 280. After having determined the equivalent number of busy days, the model input for DTD should be set equal to 1000 and ATD would then be 1000 x R.

d. Peaking Hour Characteristics. If the percent of the daily demand that occurs in the peak hour is unknown, H can be approximated by:

$$H = (1/N) \times 100$$

where

N = Number of hours in which 90% of the daily demand occurs.

7.5 Output

When the questions described in paragraph 7.3 have been answered, the program will print the annual service volume in operations per year. At this point, it is possible to do parametric variations of the last three questions of paragraph 7.3 without reentering the hourly capacity information for each runway use configuration.

> DO YOU WANT TO MAKE ANOTHER CALCULATION WITH THE SAME RUNWAY USE CAPACITIES AS BEFORE?

If YES or Y is entered, the sequence of questions starting with ENTER THE PERCENT OF THE DAILY DEMAND THAT OCCURS IN THE PEAK HOUR will be repeated. If NO or N is entered, the following question is asked:

> DO YOU WANT TO COMPUTE ADDITIONAL ANNUAL SERVICE VOLUME?

If YES or Y is entered, the sequence of questions starting with ENTER THE NUMBER OF RUNWAY USE CONFIGURATIONS TO BE CONSIDERED will be repeated. If NO or N is entered, execution of the annual service volume program will be terminated.

The calculated annual service volume assumes that the airport is open 100% of the year. If the airport is closed Z percent of the year due to inclement weather, the annual service volume should be adjusted downward as follows:

$$\text{True ASV} = \text{ASV}(100 - Z)/100$$

7.6 Examples

The following example illustrates the use of the On-line Annual Service Volume Model Version 1:

Example 1

Compute the annual service volume (ASV) for the following conditions:

Annual demand = 115,200 and 137,400 operations
Demand on average day of peak month = 627 operations
Demand in peak hours = 10% of daily demand

Runway Geometry	Diagram Number	Mix Index	Weather	Hourly Capacity	Percent Utilization
Single	1	120	VFR	54	3
Parallel	2	120	VFR	77	45
Intersecting	43	120	VFR	75	30
Single	1	150	IFR	50	7
Parallel	2	150	IFR	60	5
Intersecting	43	150	IFR	60	5
Single	1	180	PVC	44	5

The computer dialogue for this problem is shown in Figure 7-1. The annual service volume is 129,475 operations when the annual demand is 115,200 and 154,427 when the annual demand is 137,400.

7.7 Program Listing

```
type asv.sfo
      DIMENSION HC(25),P(25),WE(25),MI(25),MAXHC(25),PMC(25),W(25)
      INTEGER ASV
      REAL P,PMC,HC,MAXHC
      STRING Q1(5),Q2(5)
      DISPLAY '                    ANNUAL SERVICE VOLUME'
      DISPLAY '                      COMPUTATION PROGRAM'
      DISPLAY '                         ASV VERSION 1'
      DISPLAY ' '
      DISPLAY ' '
      DISPLAY ' DEFINATION OF INPUT TERMS USED IN THIS PROGRAM:'
      DISPLAY '   HC=HOURLY RUNWAY CAPACITY OF A SPECIFIED RUNWAY USE CONF.'
      DISPLAY '   %= UTILIZATION PERCENT OF A SPECIFIED RUNWAY USE CONF.'
      DISPLAY '   W= WEATHER CODE;  VFR=1, IFR=2, PVC=3'
      DISPLAY '   MI=MIX INDEX= %C+%3D'
      DISPLAY' '
      DISPLAY ' '
       700 ACCEPT' ENTER THE NUMBER OF RUNWAY USE CONFIGURATIONS TO BE CONSIDE
**RED. ',N
      IF(N.GT.25) DISPLAY'THE NUMBER OF RUNWAY USE CONFIGURATIONS FOR HTIS
                                                                          CALC
ULATION PROGRAM CAN NOT EXCEED 25.'
      IF(N.GT.25) GOTO 700
      DO 10 I=1,N,1
      DISPLAY ' '
      DISPLAY ' FOR RUNWAY USE CONF. NUMBER ',I
       710 ACCEPT '       HC= ',HC(I)
      IF(HC(I).GT.400)DISPLAY'WARNING: AN HOURLY CAPACITY OF ',HC(I), 'IS
                                                                          VERY
 UNLIKELY.  PLEASE REENTER.'
      IF (HC(I).GT.400) GOTO 710
      IF(HC(I).LT.0)DISPLAY'RUN ABORTED'
      IF(HC(I).LT.0) GOTO 610
       720 ACCEPT '       %= ',P(I)
      IF(P(I).GT.100)DISPLAY' WARNING: UTILIZATION PERCENT MUST BE LESS
                                                                        THAN 1
00.  PLEASE REENTER.'
      IF(P(I).GT.100) GOTO 720
      IF(P(I).LT.1) DISPLAY' WARNING:  INPUT IS IN PERCENT (EX 40 ) NOT
                                                                        DECIMA
L (EX .40).  PLEASE REENTER'
      IF(P(I).LT.1) GOTO 720
      IF(P(I).LT.0) DISPLAY' RUN ABORTED'
      IF(P(I).LT.0)     GOTO 610
       730 ACCEPT '       W= ',WE(I)
      IF (WE(I).GT.3)DISPLAY ' WEATHER INPUT IS 1 FOR VFR, 2 FOR IFR, AND 3 FO
**R PVC.  PLEASE REENTER. '
      IF (WE(I).GT.3) GOTO 730
       740 ACCEPT '       MI= ',MI(I)
      10 CONTINUE
```

```
DISPLAY ' '
750 T=0
DO 11 I=1,N,1
T=P(I)+T
11 CONTINUE
IF(T.NE.100)DISPLAY'SUMMATION OF UTILIZATION PERCENT DOES
                                                  NOT EQUAL 100.
PLEASE REENTER',
        ' UTILIZATION
                         PERCENT FOR EACH RUNWAY USE CONFIGURATION.'
IF(T.EQ.100) GOTO 760
DO 12 I=1,N,1
DISPLAY' '
DISPLAY 'FOR RUNWAY USE CONF. NUMBER ',I
ACCEPT     '%= ',P(I)
DISPLAY' '
12 CONTINUE
GOTO 750
 760 Z=0
DISPLAY' '
DO 200 I=1,N,1
IF (HC(I).GT.Z) Z=HC(I)
200 CONTINUE
MAXHC(I)=Z
DO 210 I=1,N,1
PHC(I)=(HC(I)/Z)*100
210 CONTINUE
DO 500 I=1,N,1
IF(WE(I).EQ.1) GOTO 300
IF(WE(I).NE.1) GOTO 400
 300 IF(PHC(I).GE.90)W(I)=1;
IF(PHC(I).GE.81)  W(I)=5
IF(PHC(I).GE.66)W(I)=15;
IF(PHC(I).GE.51) W(I)=20
IF (PHC(I).LT.51) W(I)=25
GOTO 500
 400 IF (MI(I).GT.50)GOTO 410
IF (MI(I).GT.20) GOTO420
410 IF(PHC(I).GE.90)W(I)=1
IF(PHC(I).GE.81)W(I)=5
IF(PHC(I).GE.66)W(I)=15
IF(PHC(I).GE.51) W(I)=20
IF(PHC(I).LT.51) W(I)=25
GOTO 500
420IF(PHC(I).GE.90)W(I)=1
IF(PHC(I).GE.81)W(I)=3
IF(PHC(I).GE.66)W(I)=8
IF(PHC(I).GE.51) W(I)=12
IF(PHC(I).LT.51) W(I)=16
GOTO 500
430IF(PHC(I).GE.90)W(I)=1
IF(PHC(I).GE.81)W(I)=1
IF(PHC(I).GE.66)W(I)=2
IF(PHC(I).GE.51) W(I)=3
IF(PHC(I).LT.51) W(I)=4
GOTO 500
500 CONTINUE
```

```
X=0
Y=0
DO 100 I=1,N,1
X=(HC(I)*W(I)*P(I))+X
Y=(W(I)*P(I))+Y
100 CONTINUE
CW=X/Y
600 CONTINUE
 620 ACCEPT' ENTER THE PERCENT OF THE DAILY DEMAND THAT OCCURS
                                                                 IN THE PEA
K HOUR.  ',H
IF (H.LT.4)DISPLAY'WARNING: THE PERCENT OF DAILY DEMAND THAT OCCURS
                                                                       IN T
HE PEAK HOUR CAN NOT',
             ' BE LESS THAN 4%.  PLEASE REENTER.'
IF(H.LT.4) GOTO 620
IF(H.GT.20)DISPLAY'WARNING:  THE PERCENT OF THE DAILY DEMAND THAT OCCURS
** IN THE PEAK HOURS','WOULD NOT LIKELY EXCEED 20%UNDER NORMAL CONDITIONS.PLEASE
** REENTER.'
IF(H.GT.20) GOTO 620
 630 ACCEPT' ENTER THE ANNUAL TRAFFIC DEMAND.  ',ATD
IF(ATD.LT.1000)DISPLAY' WARNING:  AN ANNUAL TRAFFIC DEMAND OF ',
                                                                   ATD,' OP
ERATIONS PER YEAR IS VERY UNLIKELY.  PLEASE REENTER.  NOTE:
                                                         EXPRESS',' THREE HUND
RED THOUSAND AS 300000 NOT 300.'
IF(ATD.LT.1000)GOTO 630
IF(ATD.GT.1000000)DISPLAY'  WARNING:  AN ANNUAL TRAFFIC DEMAND
                                                                 OF ',ATD,'
 IS VERY UNLIKELY.  PLEASE REENTER.'
IF(ATD.GT.1000000) GOTO 630
 640 ACCEPT ' ENTER THE DAILY TRAFFIC DEMAND FOR THE AVERAGE DAY OF THE
**PEAK MONTH.
           ',DTD
IF (DTD.GT.4000)DISPLAY'WARNING:  A DAILY DEMAND OF ',DTD,' IS VERY
                                                                      UNLIK
ELY.  PLEASE REENTER.'
IF(DTD.GT.4000) GOTO 640
ASV=CW*(ATD/DTD)*(100/H)
DISPLAY ' '
DISPLAY '*****************************************************'
DISPLAY' ANNUAL SERVICE VOLUME= ',ASV,'OPERATIONS PER YEAR'
ACCEPT'DO YOU WANT TO MAKE ANOTHER CALCULATION WITH THE SAME RUNWAY','
**USE CAPACITIES AS BEFORE?  ',Q1
IF(Q1.EQ.'YES'.OR.Q1.EQ.'Y') GOTO 600
 610 ACCEPT'DO YOU WANT TO COMPUTE ADDITIONAL ASV?  ',Q2
IF(Q2.EQ.'YES'.OR.Q2.EQ.'Y') GOTO 700
END
```

COMPUTER DIALOGUE FOR EXAMPLE 1
FIGURE 7-1

```
 execute asv.rdl
LOADING
EXECUTION
            ANNUAL SERVICE VOLUME
              COMPUTATION PROGRAM
                 ASV VERSION 1

 DEFINATION OF INPUT TERMS USED IN THIS PROGRAM:
   HC=HOURLY RUNWAY CAPACITY OF A SPECIFIED RUNWAY USE CONF.
   %= UTILIZATION PERCENT OF A SPECIFIED RUNWAY USE CONF.
   W= WEATHER CODE;  VFR=1, IFR=2, PVC=3
   MI=MIX INDEX= %C+%3D

 ENTER THE NUMBER OF RUNWAY USE CONFIGURATIONS TO BE CONSIDERED. 7

 FOR RUNWAY USE CONF. NUMBER       1
      HC= 54
      %= 3
      W= 1
      MI= 120

 FOR RUNWAY USE CONF. NUMBER       2
      HC= 77
      %= 45
      W= 1
      MI= 120

 FOR RUNWAY USE CONF. NUMBER       3
      HC= 75
      %= 30
      W= 1
      MI= 120

 FOR RUNWAY USE CONF. NUMBER       4
      HC= 50
      %= 7
      W= 2
      MI= 150

 FOR RUNWAY USE CONF. NUMBER       5
      HC= 60
      %= 5
      W= 2
      MI= 150

 FOR RUNWAY USE CONF. NUMBER       6
      HC= 60
      %= 5
      W= 2
      MI= 150
```

```
FOR RUNWAY USE CONF. NUMBER       7
     HC= 44
     %= 5
     W= 3
     MI= 180


ENTER THE PERCENT OF THE DAILY DEMAND THAT OCCURS

IN THE PEAK HOUR.  10
 ENTER THE ANNUAL TRAFFIC DEMAND.  115200
 ENTER THE DAILY TRAFFIC DEMAND FOR THE AVERAGE DAY OF THE PEAK MONTH.

  627

*******************************************************
 ANNUAL SERVICE VOLUME=      129475  OPERATIONS PER YEAR
DO YOU WANT TO MAKE ANOTHER CALCULATION WITH THE SAME RUNWAY  USE CAPACITIES
BEFORE?  y
 ENTER THE PERCENT OF THE DAILY DEMAND THAT OCCURS

IN THE PEAK HOUR.  10
 ENTER THE ANNUAL TRAFFIC DEMAND.  137400
 ENTER THE DAILY TRAFFIC DEMAND FOR THE AVERAGE DAY OF THE PEAK MONTH.

  627

*******************************************************
 ANNUAL SERVICE VOLUME=      154427  OPERATIONS PER YEAR
DO YOU WANT TO MAKE ANOTHER CALCULATION WITH THE SAME RUNWAY  USE CAPACITIES
BEFORE?  no
DO YOU WANT TO COMPUTE ADDITIONAL ASV?  n
```

FIGURE 7-1 (Cont.)

CHAPTER 8 - BATCH CAPACITY MODEL VERSION 5 - TAXIWAY CAPACITY

8.1 Introduction

An analytic model has been developed for computing the capacity of a taxiway crossing an active runway. This model will compute the capacity of a taxiway crossing:

a) an arrival only runway,
b) a departure only runway, and
c) a runway used by arrivals and departures.

A graphical procedure for computing the capacity of a taxiway crossing a runway is contained in reference b. The procedure was developed using the model described below and input data that reflects typical operating conditions.

8.2 Taxiway Model Logic

The Taxiway Model computes capacity based on the ability of a platoon of N aircraft to cross an active runway between a pair of operations on the runway. The model will permit a taxiing aircraft to cross a runway if:

a) an airborne arrival is more than a specified time from the intersection, and

b) no aircraft (arrival or departure) is between the threshold and intersection.

The model will permit a taxiing aircraft to cross an active runway after an arrival clears the intersection if the crossing operation can occur before the arrival exits. The model will permit a taxiing aircraft to cross an active runway after a departure clears the intersection if the taxiing aircraft can clear the runway before the departure clears the runway.

The taxiway model assumes that arrival operations are evenly distributed over the hour; i.e., the time between arrival operations is equal to 3600 divided by the arrival flow rate. The model assumes the demand by taxiing aircraft to cross the active runway is always large enough to completely utilize every crossing opportunity.

8.3 Input Format

The following general instructions apply to preparing inputs to the Taxiway Capacity Model:

a. Data entry requires two card types; i.e.,

Header Card; e.g., TAXI 16

Data Card(s); e.g., 30 200 300 450

b. There is no fixed sequence for groups of header/data cards.

c. Unless otherwise noted on the form by decimal points, right justify numbers.

d. To execute a run, place a 1 in card column 12 of the header card for the last data group.

e. Multiple runs can be made with one stack of cards. Place replacement header/data cards after the execute card for the first complete run.

f. The space between card columns 13 and 80 on all header cards can be used to print explanatory text (e.g., TAXIWAY BRAVO CAPACITY).

g. Any six letter title can be used in card columns 1-6 of the header card.

h. On the header card:

cc	1-6	Title
cc	9-10	Data type number
cc	12	Execute command (i.e., 1)
cc	13-80	Text

A sample coding form with header labels and decimal points is shown in Figure 8-1. It is recommended that a similar form be used to prepare card inputs. The definition of terms used in the coding form are given below:

<u>TERM</u>	<u>DEFINITION</u>
NEWRUN	A header label used with model/strategy data.
MODEL	The model number for taxiway capacity is 8.
STRATEGY	The strategy number for taxiway capacity is 1.
RUNWAY	A header label used with the mix of aircraft on the runway.
A	Class A aircraft
B	Class B aircraft
C	Class C aircraft
D	Class D aircraft

ATCBR	A header label used with the time (in seconds) required for an arrival to go from over threshold to clear of the taxiway/runway intersection being analyzed.
DTCBR	A header label used with the time (in seconds) required for a departure to go from over threshold to clear of the taxiway/runway intersection being analyzed.
TAXI	A header label.
TAXI VEL	Average aircraft taxiing velocity in miles per hour.
AC SIZE	Aircraft size in feet.
RW CLR	Runway crossing length (sometimes referred to as runway clearance distance) in feet. Runway crossing length could be interpreted to be: 1. The distance from the taxiway hold line to the location where the aircraft is considered clear of the runway. 2. The runway width + distance from taxiway hold line to runway edge + length of aircraft.
HEADWAY	Headway distance between taxiing aircraft in feet.
FRATE	A header label used with flow rate (i.e., operations per hour) of arrivals and departures on runway.
T1	Required time separation between an inbound arrival and a taxiing A class aircraft at the completion of the crossing in seconds.
T2	Required time separation between an inbound arrival and a taxiing B class aircraft at the completion of the crossing in seconds.
T3	Required time separation between an inbound arrival and a taxiing C class aircraft at the completion of the crossing in seconds.
T4	Required time separation between an inbound arrival and a taxiing D class aircraft at the completion of the crossing in seconds.
%ARR	Percent arrival on runway.
BUFF A	Buffer time (in seconds) for ATCBR.

BUFF D Buffer time (in seconds) for DTCBR.

PD Percent departure only

If percent arrival is greater than 25, PD can be 0.

The value of PD is determined from the runway capacity model. It is the percent of the time that gaps must be created in the arrival stream of a single runway to get off departures.

The headers APPSPD, DRBAR, TD, ARBAR2, EXIPT and TGRBAR are the same as defined in Chapter 2.

8.4 Input Considerations

Storage. The taxiway capacity model assumes that adequate storage exists to allow every gap to be fully utilized. For parallel runways with arrivals on the outboard runway, the following cases should be considered:

a. If no aircraft can be stored between the runways or crossing operations are given priority over departure operations, the Taxiway Capacity Model should not be used. Instead, the parallel runways should be analyzed as a single runway with the arrival runway occupancy time increased to account for taxi time between the runways.

b. If only one aircraft can be held between the runways, the taxiway capacity can be determined by entering a headway distance of 2600 feet. This will insure a headway separation of at least 2 minutes between cross ng operations.

If storage capabilities exists for two or more aircraft, the impact of storage can be considered to be slight. Detail analysis of a finite storage capability can be analyzed by the Delay Simulation Model described in Chapter 4.

Taxiway Mix. The model does not specifically consider the mix of aircraft on the taxiway crossing the runway. The input values for taxi velocity, aircraft size, runway clearance and headway should be the weighted average for the aircraft mix on the taxiway. An on-line program to calculate these inputs is given in Appendix C.

8.5 Output

The output of the Taxiway Capacity Model is the total number of taxiing operations that can cross an active runway at one point under the specified conditions. The output is for one taxiway crossing one runway. The capacity of each crossing taxiway must be calculated separately.

The capacity for a system of taxiways crossing an active runway is not necessarily equal to the summation of the taxiway capacity for each taxiway. To compute the capacity of a system of taxiways crossing an active runway, the following factors must be considered:

a. Capacity of the runway feeding the exit taxiway system
b. Aircraft mix on the runway feeding the exit taxiway system
c. Percent arrival on the runway feeding the exit taxiway system
d. Exit utilization percentages from the runway feeding the exit taxiway system
e. Departure demand on each taxiway crossing an active runway
f. Crossing capacity of each taxiway

On-line programs to calculate the capacity of a system of taxiways crossing an active runway and the combined capacity of a feeder runway and exit taxiway system are given in Appendix C.

8.6 Data Input Modes

It is possible to use the Taxiway Capacity Model in two input modes; i.e.,

- o Remote Job Entry (RJE) via cards
- o From a teletype terminal using stored files

The remote job entry requires that all data be punched on IBM cards and be processed by a card reader (e.g., DATA 100). Job cards are required to load the capacity model and to identify the user for billing purposes. Model output is printed on a remote printer.

In the teletype terminal mode the user can construct input files and call for model executions directly from his work area. The input format is exactly the same as with cards. To call for an execution a series of computer instructions are entered at the teletype terminal. These instructions can themselves be stored in the computer and called for by a Command File or CLIST.

The FAA has established Command Files on TYMSHARE and McAuto for operation of the Taxiway Capacity Model from a teletype terminal. To use this method the input data must be placed in a temporary file named BATCH.SUB and the command EX TER be entered. This will result in a complete execution of the Taxiway Capacity Model. After execution, the input file BATCH.SUB can be renamed and permanently stored, or edited and reexecuted.

8.7 <u>Examples</u>

The following example illustrates the use of the Taxiway Capacity Model:

<u>Example 1</u>

Compute the capacity of a taxiway crossing a runway 4000 feet from the runway threshold. The runway has a demand of 20 arrivals and 20 departures. The aircraft mix on the runway is: 20%A, 30%B, 40%C and 10%D. Assume typical values for all other input parameters; i.e., values used to generate Figure 2-66 in reference b.

Figure 8-2 shows the coding form for the Taxiway Capacity Model with input data filled in. From the computer output shown in Figure 8-3, the crossing capacity is 47.7 operations/hour.

DAC 25-1212C (REV 8-69)

CODING FORM FOR BATCH CAPACITY MODEL VERSION 5

FIGURE 8-1

TAXIWAY CAPACITY

Cols 1–4	Cols 5–8	Cols 9–12	Cols 13–16	Cols 17–20	Cols 21–24	Cols 25–28	Cols 29–32	Cols 33–36	Cols 37–40	Cols 41–44	Cols 45–48	Cols 49–52	Cols 53–56	Cols 57–60	Cols 61–64
N E W R	U N														
model	strategy														
8	1														
R U N W	A Y 1	1													
a	b	c	d												
0 .	0 .	0 .	0 .												
A T C B	R	1 4													
a	b	c	d												
.	.	.	.												
D T C B	R	1 5													
a	b	c	d												
.	.	.	.												
T A X I		1 6													
taxi vel	ac size	rw clr	headway												
A P P S	P D	5													
a	b	c	d												
D R B A	R	6													
a	b	c	d												
T D		7													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd

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CODING FORM FOR BATCH CAPACITY MODEL VERSION 5 FIGURE 8-1

TAXIWAY CAPACITY

```
ARBAR2 1 2
a
  .   .   .   .   .   .   .   .   .   .   .
b
  .   .   .   .   .   .   .   .   .   .   .
c
  .   .   .   .   .   .   .   .   .   .   .
d
  .   .   .   .   .   .   .   .   .   .   .
EXIPT  1  3
a
 .   .   .   .   .   .   .   .   .   .   .
b
 .   .   .   .   .   .   .   .   .   .   .
c
 .   .   .   .   .   .   .   .   .   .   .
d
 .   . .   .   .   .   .   .   .   .   .   .
TGRBAR    9 1
  a    b   c   d
  .    .   .   .
FRATE    21
  t1   t2   t3   t4  frate  %arr  buff a  buff b  pd
  .    .    .    .   .      .     .       .      0.
```

CODING FORM FOR BATCH CAPACITY MODEL VERSION 5

COMPLETED CODING FORM FOR EXAMPLE 1
FIGURE 8-2

TAXIWAY CAPACITY

NEWR	UN			CARL BALL 426-3685											
model	strategy														
8	1														
RUNW	AY 1	1													
a	b	c	d												
0.20	0.30	0.40	0.10												
ATCB	R	14													
a	b	c	d												
32.	40.	38.	35.												
DTCB	R	15													
a	b	c	d												
29.	32.	30.	30.												
TAXI		16													
taxi vel	ac size	rw clr	headway												
15	150	450	600												
APPS	PD	5													
a	b	c	d												
95	120	130	140												
DRBA	R	6													
a	b	c	d												
29	34	39	39												
TD		7													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
50	56	60	60	55	55	60	60	60	60	60	60	120	120	120	90

DAC 25-1212C (REV 8-69)

CODING FORM FOR BATCH CAPACITY MODEL VERSION 5

COMPLETED CODING FORM FOR EXAMPLE 1
FIGURE 8-2

TAXIWAY CAPACITY

1-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32	33-36
ARBA	R2 1	2						
a								
32.0	.	.	.	.	.	.	.	.
b								
40.0	.	.	.	.	.	.	.	.
c								
51.0	.	.	.	.	.	.	.	.
d								
58.0	.	.	.	.	.	.	.	.
EXIP	T 1	3						
a								
1.0	.	.	.	.	.	.	.	.
b								
1.0	.	.	.	.	.	.	.	.
c								
1.0	.	.	.	.	.	.	.	.
d								
1.0	.	.	.	.	.	.	.	.
TGRB	AR	9 1						
a	b	c	d					
23.	22.	27.	27.					
FRAT	E	21						
t1	t2	t3	t4	frate	%arr	buff a	buff b	pd
30.	30.	30.	30.	40.	50.	10.	10.	0.0

```
NEWRUN 0 0 0                                                                    000000
   8   1   0
TW     1 1 0                                                                    000000
0.200.300.400.10
ATCBR  014 0                                                                    000000
32.040.038.035.0
DTCBR  015 0                                                                    000000
29.032.030.030.0
TAXI   016 0                                                                    000000
  15 150 450 600 0.0 0.0
APPSPD 0 5 0                                                                    000001
  95 120 130 140
DRBAR  0 6 0                                                                    000001
  29  34  39  39
TD     0 7 0                                                                    000001
  50  50  60  60  55  55  60  60  60  60  60  60 120 120 120  90
ARBAR2 1 2 0                                                                    000001
32.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
40.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
51.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
58.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
EXIPT  1 3 0                                                                    000002
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.000.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
TGRBAR 0 9 0                                                                    000002
23.022.027.027.0
FRATE  021 1                                                                    000003
30.030.030.030.040.050.010.010.00.0

                  TAXIWAY CROSSING CAPACITY IS     47.7  OPERATIONS PER HOUR
                  WHEN RUNWAY FLOW RATE IS  40.0  OPERATIONS PER HOUR  WITH
```

COMPUTER OUTPUT FOR EXAMPLE 1

FIGURE 8-3

CHAPTER 9 - BATCH CAPACTIY MODEL VERSION 5 - GATE CAPACITY

9.1 Introduction

The Gate Capcity Model computes the maximum number of aircraft that could be expected to operate on a set of gates in 1 hour under specified conditions. Gate capacity, like runway capacity, is calculated as the inverse of a weighted average service time for all aircraft being served.

A graphical procedure for computing the capacity of a set of gates is contained in reference b. The procedure was developed using the model described below.

9.2 Model Logic

To compute gate capacity, the model will consider two different conditions:

a) All gates can accommodate all aircraft classes.
b) Some gates cannot accommodate all aircraft classes.

The capacity of condition a) is the quotient of the number of gates and the weighted average gate occupancy time. The capacity of condition b) is the product of the capacity of condition a) and a restriction factor which represents the loss of capacity due to the nonavailability of gates of an appropriate size.

To determine the restriction factor on gate availability, the Gate Capacity Model considers two classes of aircraft:

a) Standard - aircraft which could use all gates
b) Large - aircraft which are restricted from using some gates because of the physical dimensions of the gate

If the proportion of the total time required to service large aircraft is less than or equal to the proportion of gates for large aircraft to total gates, no restriction to the flow of large jets exists; i.e., the restriction factor equals one. However, if it is greater, there is a restriction on the maximum flow potential. In this case, the restriction is the quotient of the proportion of gates for large aircraft and the proportion of the total gate time required by large aircraft. To illustrate the gate restriction factor consider:

	Number of Gates	Mix	Gate Occupancy Time
Large Aircraft	10	40%	60 minutes
Standard Aircraft	20	60%	45 minutes

The proportion of gates for large aircraft = $q(1) = 10/30 = .33$

The proportion of the total gate time for large aircraft =

$$t(1) = \frac{.40 \times 60}{(.40 \times 60) + (.60 \times 45)} = .47$$

Since $t(1)$ is greater than $q(1)$, the restriction factor on the maximum flow potential X is:

$$X = .33/.47 = 0.7$$

9.3 Input Format

The following general instructions apply to preparing inputs to the Gate Capacity Model:

a. Data entry requires two cards; i.e.,

Header Card; e.g.,	GOT	17
Data Card; e.g.,	55 65	

b. There is no fixed sequence for groups of header/data cards.

c. Unless otherwise noted on the form by decimal points, right justify numbers.

d. To execute a run, place a 1 in card column 12 of the header card for the last data group.

e. Multiple runs can be made with one stack of cards. Place replacement header/data cards after the execute card for the first complete run.

f. The space between card columns 13 and 80 on all header cards can be used to print explanatory text (e.g., NORTH GATE COMPLEX).

g. Any six letter title can be used in card columns 1-6 of the header card.

h. On the header card:

cc	1-6	Title
cc	9-10	Data type number
cc	12	Execute command (i.e., 1)
cc	13-80	Text

A sample coding form with header labels and decimal points is shown in Figure 9-1. It is recommended that a similar form be used in preparing card inputs. The definitions of terms used in the coding form are given below:

TERM	DEFINITION
NEWRUN	- A header label used with model/strategy data.
GOT	- The header label used with gate occupancy time in seconds.
SGOT	- Gate occupancy time for standard aircraft.
LGOT	- Gate occupancy time for large aircraft.
GATES	- The header label used with the number of gates per aircraft class.
LG	- Number of gates that can be used by large aircraft.
SG	- (Total number of gates) - (Number of gates that can be used by large aircraft.)
MIX	- The header label used with the mix of aircraft on the gates.
SM	- Percent of standard aircraft.
LM	- Percent of large aircraft.

9.4 Input Considerations

The following factors should be considered in preparing inputs for the Gate Capacity Model:

a. Airline Gates Versus Common Use Gates. In general, airlines do not share gates assigned to them with other airlines. This can be considered in a gate capacity analysis by determining which gates are assigned to each airline and making a capacity run for each set of exclusive use airline gates. Input data (i.e., aircraft mix, gate occupancy time, number of large and standard gates) must be developed to reflect conditions appropriate to each set of gates. The case where all gates can be used by all airlines can be analyzed by determining inputs appropriate for the total gate complex. It should be noted that the total gate capacity as determined by summing the gate capacities for each airline will, in general, be less than the gate capacity assuming all airlines can use all gates.

b. General Aviation Basing Area. The Gate Capacity Model should not be used to compute the capacity of a general

aviation basing area because general aviation operations do not tend to be turnaraound operations.

c. Gate Mix Versus Runway Mix. The aircraft mix used in the Gate Capacity Model will generally not be identical to the aircraft mix used in the Runway Capacity Model because general aviation aircraft do not usually use the gates and the fleet of aircraft for each airline is different.

d. Gate Sharing Within an Airline. The Gate Capacity Model assumes that gates serving large aircraft can also be used by standard aircraft. If all or part of the gates serving large aircraft are not used by standard aircraft, divide the gates of the airline into:

1) Those used only by large aircraft.

2) Those used by standard aircraft, and those shared by large and standard aircraft.

Make separate runs for each case. The gate capacity for the airline would be the sum of these conditions.

e. Identifiable Gate. It is often difficult to determine the exact number of gates because:

1) Some aircraft (e.g., Heavy Jets) may encroach on the area of one or more adjacent gates rendering them unuseable by other aircraft. This condition is known as gate blocking.

2) Some gate positions in the terminal building are served by two or more remote parking positions.

The Gate Capacity Model does not explicitly consider the effect on capacity of gate blocking. This factor can be considered by separately determining how often and to what extent this phenomonen occurs. It is reocmmended that remote parking positions be analyzed as a separate subset of the toal number of gates.

f. Aircraft Mix. It is sometimes necessary to consider more than two aircraft classes in analyzing the capacity of a particular set of airline gates. This can be accomplished by subdividing the airline gates according to the size of aircraft that can use them. For example, if gate numbers:

1, 2, 3 and 7 are to be used only by A & B aircraft;
4, 5 and 9 are to be used only by C aircraft; and
6, 8 and 10 are to be used only by C & D aircraft;

divide the gate capacity for this airline into an analysis of gates 1, 2, 3 and 7 and a separate analysis of gates 4, 5, 6, 8, 9 and 10.

g. Capacity Analysis Versus Scheduling Analysis. The purpose for which the gate capacity is calculated can influence the input for gate occupancy time by aircraft class. If gate capacity is used with the delay curve given in reference b, gate occupancy times should be consistent with observed gate occupancy times. If, however, the gate capacity is used to determine how many aircraft an airline could schedule to use a particular number of gates, the gate occupancy time would most likely be increased to allow for a buffer between the departing and arriving aircraft.

h. Through Versus Turnaround Versus Connecting Versus Parked Aircraft. Through aircraft are those which unload and load passengers with a minimum amount of time being alloted for aircraft servicing. Turnaround aircraft are those with a significant amount of time built into their scheduled departure time to account for aircraft servicing. Connecting aircraft are those which coordinate their departure time with the arrival time of other aircraft. This may result in long gate occupancies. Parked aircraft are those which occupy a gate for several hours before being scheduled to depart.

In general, the gate occupancy time for through, turnaround and connecting aircraft are quite different. In determining the average gate occupancy time the occurance of through, turnaround and connecting operations should be considered. Parked aircraft should not, in general, be considered in a gate capacity analysis. If parked aircraft are considered in the capacity analysis, do not include these gates as part of an airline gate set.

As illustrated by the above, a significant part of a gate capacity analysis is involved in determining factors that limit the unconstrained use of gates and incorporating these detailed considerations into a series of model runs.

9.5 Output

The Gate Capacity Model provides three capacity measures from each run:

a. The capacity assuming all gates can be used by all aircraft. An example of the printout for this measure is:

GATE CAPACITY SIMPLIFIED MODEL 30 PER HOUR.

b. The capacity considering that some gates cannot be used by all aircraft. An example of the printout for this measure is:

GATE CAPACITY GENERAL MODEL 25 PER HOUR.

c. The restriction factor on gate availability. An example of the printout for this measure is:

MOST SEVERE RESTRICTION TO MAXIMUM FLOW 0.70.

9.6 Data Input Modes

It is possible to use the Gate Capcity Model in two input modes; i.e.,

- Remote Job Entry (RJE) via cards
- From a teleyppe terminal using stored files

Remote job entry requires that all data be punched on IBM cards and be processed by a card reader (e.g., DATA 100). Job cards are required to load the capacity model and to identify the user for billing purposes. Model output is printed on a remote printer.

In the teletype terminal mode the user can contruct input files and call for model executions directly from his work area. The input format is exactly the same as with cards. To call for an execution, a series of computer instructions are entered at the teletype terminal. These instructions can be stored in the computer and called for by a Command File or CLIST.

The FAA has established Command Files on TYMSHARE and McAuto for operation of the Gate Capacity Model from a teletype terminal. To use this method, the input data must be placed in a temporary file named BATCH.SUB and that the command EX TER be entered. This will result in a complete execution of the Gate Capacity Model After execution, the input file BATCH.SUB can be renamed and permanently stored, or edited and reexecuted.

9.7 Examples

The following example illustrates the use of the Gate Capacity Model:

Example 1

Compute the capacity of the following gate complex:

4 gates that can only be used by C class aircraft
6 gates that can be used by C or D aircraft
Aircraft Mix: 60%C and 40%D
Gate Occupancy Time:

45 minutes for C aircraft
55 minutes for D aircraft

Figure 9-2 shows the coding form for the Gate Capacity Model with input data filled in. From the computer output shown in Figure 9-3, the capacity of this gate complex is 12.24 operations per hour.

CODING FORM FOR BATCH CAPACITY MODEL VERSION 5

FIGURE 9-1

GATE CAPACITY

```
N E W R U N
        9       1
G O T             1 7
sgot    lgot
G A T E S         1 8
sg      lg
M I X             1 9   1
sg      lg
0 .     0 .
```

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CODING FORM FOR BATCH CAPACITY MODEL VERSION 5

COMPLETED CODING FORM FOR EXAMPLE 1
FIGURE 9-2

GATE CAPACITY

1	2	3	4	5	6	7	8	9	10	11	12
N	E	W	R	U	N						
			9				1				
G	O	T						1	7		
sgot				lgot							
		4	5			5	5				
G	A	T	E	S				1	8		
sg				lg							
			4				6				
M	I	X						1	9		1
sg				lg							
0	.	6	0	0	.	4	0				

```
NEWRUN 0 0 0                                        00000010
   9   1   0
GOT    017 0                                        00000030
  45  55
GATES  018 0                                        00000050
   4   6
MIX    019 1                                        00000070
0.600.40
GATE CAPACITY SIMPLIFIED MODEL  12.24   PER HOUR
GATE CAPACITY GENERAL MODEL     12.24   PER HOUR
MOST SEVERE RESTRICTION TO MAXIMUM FLOW   1.00
READY
```

COMPUTER OUTPUT FOR EXAMPLE 1

FIGURE 9-3

APPENDIX A PERCENT ARRIVAL TECHNIQUE MODEL

A.1 Introduction

This appendix presents a utility on-line program for computing percent arrival. This technique can be used to:

a) Compute the capacity of a runway use configuration for a given percent arrival.

b) Compute the capacity of some runway use configurations not shown in Figure 2-1.

c) Produce capacity versus percent arrival sensitivity curves with only one run of the Runway Capacity Model.

Copies of this utility program are not available for distribution. A listing of the program is contained in paragraph A.6. The model is currently available for use on TYMSHARE.

A.2 Model Logic

The percent arrival technique is based on the capacity of a basic runway use configuration and a revised runway use configuration. The basic runway use configuration is defined as the input runway use configuration with preemptive arrival priority. The revised runway use configuration is defined as an operational subset of the basic runway use configuration which is used to bring departure capacity up to the desired proportion of arrival capacity. The revised runway use configuration is determined by eliminating all stream(s) that could influence the departure stream(s). For example, if the basic runway use configuration was mixed operations on a single runway (i.e., Model 1-3), the revised runway use configuration would be departures only on a single runway (i.e., Model 1-2). Figure A-1 contains a listing of revised runway use configurations (in terms of model numbers) that may be used with basic runway use configurations.

The model logic is as follows:

If PA = desired percent arrivals.
A1 = arrival capacity of the basic runway use configuration.
D1 = departure capacity of the basic runway use configuration.
A2 = arrival capacity of the revised runway use configuration with all arrival stream(s) eliminated which could influence departure stream(s).
D2 = departure capacity of revised runway use configura-

tion with all arrival stream(s) eliminated which could influence departure capacity.

Check the inequality

$$PA \geq \frac{A1}{A1+D1} \qquad (1)$$

If this inequality holds, then

CAPACITY = A1/PA

and the percent arrivals is PA as specified.

If inequality (1) does not hold, check the inequality

$$PA \geq \frac{A2}{A2 + D2} \qquad (2)$$

If this inequality holds, compute

$$p = \frac{(A2 + D2)\ PA - A2}{(A1 - A2) + (A2 + D2 - (A1 + D1))\ PA}$$

where p is the proportion of time the basic runway use applies and 1 - p is the proportion of time the revised runway use applies.

Now

CAPACITY = (A1 + D1) p + (A2 + D2) (1 - p)

and the percent arrivals is PA as specified.

If inequality (2) does not hold, compute

$$CAPACITY = \frac{D2}{1 - PA}$$

and percent arrivals is PA as specified.

A.3 Input Format

The percent arrival technique can be executed via the command EXECUTE PA.SFO. The first question is:

ENTER DESIRED % ARRIVALS:

Any integer from 0 to 100 can be input. The next question is:

ENTER ARRIVAL CAPACITY OF BASIC RUNWAY USE CONFIGURATION:

This input would come from a run of the Runway Capacity Model for the desired runway use configuration and 9999 entered for percent arrival. Any integer from 0 to 240 can be input. The next question is:

ENTER DEPARTURE CAPACITY OF BASIC RUNWAY USE CONFIGURATION:

This input would come from a run of the Runway Capacity Model for the desired runway use configuration and 9999 entered for percent arrival. Any integer from 0 to 240 can be input.

If inequality (1) is true, no further input questions will be asked. If inequality (1) is not true, the next question is:

ENTER ARRIVAL CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL STREAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS.

This input would come from a run of the Runway Capacity Model for the revised runway use configuration and 9999 entered for percent arrival. Any integer from 0 to 240 can be input. The next question is:

ENTER DEPARTURE CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL STREAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS.

This input would come from a run of the Runway Capacity Model for the revised runway use configuration and 9999 entered for percent arrival. Any integer from 0 to 240 can be entered.

A.4 Output

The output of the percent arrival technique is the total capacity of the runway use configuration for the input percent arrival, and capacities. Following the printing of the total capacity, the model can be used to compute the sensitivity of total capacity to variations of percent arrival:

DO YOU WANT A SENSITIVITY ANALYSIS OF CAPACITY TO PERCENT ARRIVAL?

A Y or YES response will result in total capacity being computed for values of percent arrival ranging from 0 to 100 in increments of 5%. A N or No response will result in the question:

DO YOU WANT TO MAKE ANOTHER CALCULATION?

A Y or YES response will result in the question:

ENTER DESIRED % ARRIVALS:

The model will then ask for new values of arrival and departure capacity for the basic and revised runway use configurations. A N or NO response will terminate the program.

A.5 Examples

The following illustrates the use of the on-line program for computing percent arrivals.

Example 1

Compute the hourly capacity for the following conditions:

PA = 45%
A1 = 35   D1 = 15
A2 = 0   D2 = 55

Also, compute the sensitivity of hourly capacity to percent arrivals. The computer dialogue for this problem is shown in Figure A-2. The capacity at 45% arrival is 51 operations per hour. The sensitivity of capacity to percent arrivals is:

Percent Arrivals	Hourly Capacity
0	55
5	55
10	54
15	54
20	53
25	53
30	53
35	52
40	52
45	52
50	51
55	51
60	51
65	50
70	50
75	47
80	44
85	41
90	39
95	37
100	35

Example 2

If an airport is composed of two runway use configurations that are independent from an air traffic control standpoint, compute the hourly capacity at 50% arrivals for the following conditions:

Runway Use Configuration 1		Runway Use Configuration 2	
A1 = 35	D1 = 10	A1 = 35	D1 = 20
A2 = 0	D2 = 55	A2 = 0	D2 = 55

The combined arrival and departure capacities are:

A1 = 70	D1 = 30
A2 = 0	D2 = 110

The computer dialogue for this problem is shown in Figure A-3. The capacity at 50% arrival is found to be 102 operations per hour.

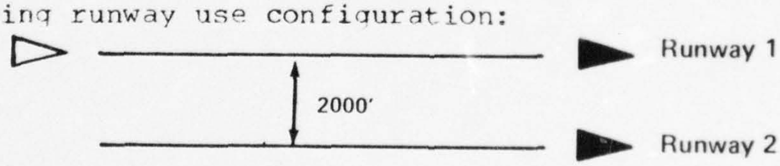
NOTE: If the 50% capacity had been calculated for each runway use configuration separately (computer run not shown), the total capacity would be:

Runway Use Configuration 1 =	48
Runway Use Configuration 2 =	55
Total	103

The difference in total capacity results because combining the arrival and departure components of capacity for both runway use configurations allows Runway Use Configuration 2 to supplement the capacity of Runway Use Configuration 1; i.e., more aircraft are allowed to use Runway Use Configuration 2 than Runway Use Configuration 1.

Example 3

Compute the VFR hourly capacity for 50% arrival of the following runway use configuration:



The operation is such that only 10 departures are permitted to use runway 2 each hour.

The capacity without regard to percent arrival (i.e., 9999 input for percent arrival) for runway 1 is:

ARRIVALS =	35
DEPARTURES =	15
TOTAL	50

The departure only capacity of runway 1 is 60 operations per hour and the departure only capacity of runway 2 is 60 operations per hour.

From this data the model inputs are:

A1 = 35	D1 = 25	i.e., 15 + 10
A2 = 0	D2 = 70	i.e., 60 + 10

The computer dialoque is shown in Fiqure A-4. The hourly capacity is found to be 61 operations per hour.

NOTE: If the operational restriction was not placed on runway 2, the model inputs would be:

A1 = 35	D1 = 75	i.e., 60 + 15
A2 = 0	D2 = 120	

The capacity would be 70 operations per hour (calculation not shown).

A.6 Program Listing

```
type pa.sfo
      DIMENSION PA(20),A1(20),D1(20),A2(20),D2(20)
       INTEGER CAP
       REAL PA,A1,D1,A2,D2
       STRING S1(6)
      STRING S2(6)
      DISPLAY "     "
      DISPLAY "     "
      DISPLAY "     "
      DISPLAY "     "
      DISPLAY "     "
      DISPLAY "                    ****** PERCENT ARRIVALS TECHNIQUE ****** "
      DISPLAY "                           FOR ALL R/W CAPACITY MODELS "
       DISPLAY "  "
       DISPLAY "  "
      77  DISPLAY ""
       DO 22 I=1,N,1
      DISPLAY "     "
      30  ACCEPT "ENTER DESIRED % ARRIVALS:    ",PA(I)
      IF(PA(I) .LT. 0 .OR. PA(I) .GT. 100) DISPLAY"WARNING: % ARRIVALS MUST B
**E 0-100,PLEASE RE-ENTER"
      PA(I)=PA(I)/100
      IF(PA(I) .LT. 0 .OR. PA(I) .GT. 100) GO TO 30
      40  ACCEPT "ENTER ARRIVAL CAPACITY OF BASIC RUNWAY USE CONFIGURATION:
** ",A1(I)
      IF(A1(I) .GT. 240 .OR. A1(I) .LT. 0) DISPLAY"AN HOURLY ARRIVAL CAPACITY
** OF ",A1(I),"VERY UNLIKELY AND UNUSUAL,PLEASE CHECK AGAIN TO SEE IF THIS IS WH
**AT YOU REALLY WANT, THEN RE-ENTER"
      IF(A1(I) .GT. 240 .OR. A1(I) .LT. 0) GO TO 40
      50  ACCEPT "ENTER DEPARTURE CAPACITY OF BASIC RUNWAY USE CONFIGURATION:
**   ",D1(I)
      IF(D1(I) .GT. 240 .OR. D1(I) .LT. 0) DISPLAY "AN HOURLY DEPARTURE CAPAC
**ITY OF ",D1(I)," IS VERY UNLIKELY"
     IF(D1(I) .GT. 240 .OR. D1(I) .LT. 0) GO TO 50
      DISPLAY "  "
      B=A1(I)/(A1(I)+D1(I))
      IF(PA(I) .LT. B) GO TO 60
      CAP=A1(I)/PA(I)
      A2(I)=0
      D2(I)=0
      GO TO 100
      60  ACCEPT "ENTER ARRIVAL CAPACITY OF REVISED RUNWAY USE CONFIGURATION
**WITH ALL ARRIVAL STREAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:
**",A2(I)
      DISPLAY "   "
     IF(A2(I).GT.400) DISPLAY' AN HOURLY ARRIVAL CAPACITY OF',A2(I),'IS VERY
**UNLIKELY, PLEASE CHECK AGAIN AND RE-ENTER.'
      IF(A2(I) .GT. 400) GOTO 60
      65  ACCEPT "ENTER DEPARTURE CAPACITY OF REVISED RUNWAY USE CONFIGURATIO
**N WITH ALL ARRIVAL STREAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:
**  ",D2(I)
      IF(D2(I) .GT. 400 .OR. D2(I) .LT. 1) DISPLAY "AN HOURLY DEPARTURE CAPAC
**ITY OF ",D2(I)," IS VERY UNLIKELY,PLEASE CHECK AGAIN,THEN RE-ENTER"
     IF(D2(I) .GT. 400 .OR. D2(I) .LT. 1) GO TO 65
      35  C=A2(I)/(A2(I)+D2(I))
      IF(PA(I) .LT. C) GO TO 38
```

```
      F=A2(I)+D2(I)
      G=A1(I)+D1(I)
      R=A1(I)-A2(I)
      Y=(F*PA(I)-A2(I))/(R+(A2(I)+D2(I)-G)*PA(I))
      Z=1-Y
      CAP=G*Y+F*(1-Y)
      DISPLAY "  "
      DISPLAY "PROPORTION OF TIME BASIC RUNWAY USE APPLIES =  ",Y,"    "
      DISPLAY "PROPORTION OF TIME REVISED RUNWAY USE APPLIES =  ",Z,"  "
      DISPLAY "  "
      DISPLAY "  "
      DISPLAY "  "
      DISPLAY "                              (OPTION  1) "
      GO TO 100
      38  CAP=D2(I)/(1-PA(I))
      DISPLAY "  "
      DISPLAY "  "
      DISPLAY "  "
      DISPLAY "  "
      DISPLAY "                              (OPTION  2) "
      100  DISPLAY "                  ********************************************
**"
      DISPLAY "  "
      DISPLAY "   "
      DISPLAY "    "
      DISPLAY "   "
      DISPLAY "                 CAPACITY  =  ",CAP," OPERATIONS PER HOUR"
      DISPLAY "   "
      DISPLAY "   "
      DISPLAY "   "
      DISPLAY "  "
      46  ACCEPT "DO YOU WANT A SENSITIVITY ANALYSIS OF PERCENT ARRIVALS TO C
**APACITY?  ",S2
      DISPLAY "   "
      DISPLAY "   "
      DISPLAY "    "
      IF(S2 .EQ. "YES" .OR. S2 .EQ. "Y")DISPLAY "     % APR.      CAP."
      IF(S2 .EQ. "YES" .OR. S2 .EQ. "Y")DISPLAY "    ********    ******"
      DISPLAY "   "
      IF(S2 .EQ. "YES" .OR. S2 .EQ. "Y") GO TO 47
      IF(S2 .EQ. "NO" .OR. S2 .EQ. "N") GO TO 45
      IF(S2 .NE. "YES" .OR. S2 .NE. "Y") DISPLAY "PLEASE ENTER YES OR NO,YOU
**CAN ALSO ENTER Y OR N "
      IF(S1 .NE. "YES" .OR. S1 .NE. "Y") GO TO 46
      22  CONTINUE
      47  DO 55 I= 1,101,5
      REAL J,K,L,M,N
      J=I-1
      P=A1(1)
      Q=D1(1)
      V=A2(1)
      S=D2(1)
      T=P/(P+Q)
      J=J/100
```

```
      IF(J .LT. T)GO TO 13
      W=P/J
      J=J*100
      GO TO 66
      13  J=J*100
      27  IF(V .EQ. 0 .AND. S .EQ. 0)DISPLAY "FOR "J" PERCENT ARR.YOU NEED AR
**R.& DEPT.CAP.OF REVISED R/W "
      IF(V .EQ. 0 .AND. S .EQ. 0) GO TO 55
      28  U=V/(V+S)
      J=J/100
      IF(J .LT. U)GO TO 29
      K=V+S
      L=P+Q
      M=P-V
      N=((V+S)*J-V)/(M+(K-L)*J)
      W=L*N+K*(1-N)
      J=J*100
      GO TO 66
      29  W=S/(1-J)
      J=J*100
      66  WRITE(1,300) J,W
      300  FORMAT(5X,I4,7X,I4)
      55  CONTINUE
      45  ACCEPT "DO YOU WANT TO MAKE ANOTHER CALCULATION?   ",S1
      A1(I)=0
      A2(I)=0
      D1(I)=0
      D2(I)=0
      IF(S1 .EQ. "YES" .OR. S1 .EQ. "Y") GO TO 77
      IF(S1 .EQ. "NO" .OR. S1 .EQ. "N") GO TO 80
      IF(S1 .NE. "YES" .OR. S1 .NE. "Y") DISPLAY "PLEASE ENTER  YES  OR  NO
**,YOU CAN ALSO ENTER  Y  OR  N "
      IF(S1 .NE. "YES" .OR. S1 .NE. "Y") GO TO 45
      80  STOP
      END
```

BASIC MODEL	REVISED VFR MODEL	REVISED IFR MODEL	BASIC MODEL	REVISED VFR MODEL	REVISED IFR MODEL
1-3	1-2	1-2			
			4-13	4-21	4-21
2-4	2-2	2-2	4-15	4-21	4-21
2-6	2-3	2-3	4-17	4-21	4-21
2-10	2-8	2-8	4-19	4-24	4-24
2-11	2-9	2-9			
2-12	2-9	2-9	5-2	1-2	1-2
2-17	2-15	2-15	5-3	5-1	5-1
2-18	2-15	2-15	5-4	1-2	1-2
2-20	1-2	1-2	5-5	5-4	1-2
2-22	2-20	1-2			
2-23	2-21	2-21	6-2	1-2	1-2
2-24	2-21	2-21	6-3	1-2	1-2
3-1	3-28	3-28	7-4	1-2	1-2
3-2	3-29	3-29	7-5	2-21	2-21
3-3	3-29	3-29	7-6	2-9	2-9
3-4	3-22	2-20			
3-5	3-23	2-20	10-1	10-5	5-1
3-6	3-24	3-24	10-2	3-29	2-15
3-7	3-22	2-21	10-3	3-22	2-21
3-8	3-22	2-21	10-4	3-22	2-21
3-9	3-23	2-20			
3-10	3-24	3-24	11-1	2-21	2-21
3-11	3-26	2-3	11-2	4-24	2-15
3-13	3-26	3-26	11-3	2-21	2-21
3-14	3-27	3-27	11-4	2-21	2-21
3-16	1-2	1-2			
3-17	1-2	1-2	12-1	1-2	1-2
3-18	3-25	2-15	12-2	2-9	2-15
3-19	3-25	2-15	12-3	1-2	1-2
3-20	3-22	2-21	12-4	12-3	1-2
3-21	3-22	2-21			
			13-1	3-26	2-15
4-1	2-3	2-3	13-2	3-29	3-29
4-3	2-9	2-9	13-3	3-22	2-21
4-5	4-22	4-22	13-4	3-22	2-21
4-7	4-21	4-21			
4-9	4-23	4-23	14-1	2-21	2-21
4-10	4-23	4-23	14-2	4-24	2-15
4-11	4-2	2-3			
			15-1	2-21	2-21
			15-2	2-21	2-21

FIGURE A-1

BASIC & REVISED RUNWAY USE
CONFIGURATIONS FOR PERCENT ARRIVAL TECHNIQUE

COMPUTER DIALOGUE FOR EXAMPLE 1
FIGURE A-2

```
execute pa.sfo
LOADING
EXECUTION


            ****** PERCENT ARRIVALS TECHNIQUE ******
                  FOR ALL R/W CAPACITY MODELS


ENTER DESIRED % ARRIVALS:    45
ENTER ARRIVAL CAPACITY OF BASIC RUNWAY USE CONFIGURATION:   35
ENTER DEPARTURE CAPACITY OF BASIC RUNWAY USE CONFIGURATION:    15

ENTER ARRIVAL CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL STRE
AMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:   0

ENTER DEPARTURE CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL ST
REAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:   55

PROPORTION OF TIME BASIC RUNWAY USE APPLIES =        .6644295
PROPORTION OF TIME REVISED RUNWAY USE APPLIES =      .3355705


                         (OPTION  1)
             *******************************************


             CAPACITY  =        51    OPERATIONS PER HOUR


DO YOU WANT A SENSITIVITY ANALYSIS OF PERCENT ARRIVALS TO CAPACITY?   y


     % ARR.      CAP.
    ********    ******

       0          55
       5          55
      10          54
      15          54
      20          53
      25          53
```

```
     30         53
     35         52
     40         52
     45         52
     50         51
     55         51
     60         51
     65         50
     70         50
     75         47
     80         44
     85         41
     90         39
     95         37
    100         35
DO YOU WANT TO MAKE ANOTHER CALCULATION?    n
STOP
```

FIGURE A-2 (Cont.)

```
 execute pa.sfo
LOADING      --
EXECUTION



              ****** PERCENT ARRIVALS TECHNIQUE ******
                     FOR ALL R/W CAPACITY MODELS


ENTER DESIRED % ARRIVALS:    50
ENTER ARRIVAL CAPACITY OF BASIC RUNWAY USE CONFIGURATION:    70
ENTER DEPARTURE CAPACITY OF BASIC RUNWAY USE CONFIGURATION:    30

ENTER ARRIVAL CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL STRE
AMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:    0

ENTER DEPARTURE CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL ST
REAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:  110

PROPORTION OF TIME BASIC RUNWAY USE APPLIES =          .7333333
PROPORTION OF TIME REVISED RUNWAY USE APPLIES =        .2666667


                            (OPTION  1)
             ******************************************


             CAPACITY  =         102   OPERATIONS PER HOUR


DO YOU WANT A SENSITIVITY ANALYSIS OF PERCENT ARRIVALS TO CAPACITY?    n


DO YOU WANT TO MAKE ANOTHER CALCULATION?    n
STOP
```

COMPUTER DIALOGUE FOR EXAMPLE 2

FIGURE 7-3

```
 execute pa.sfo
LOADING
EXECUTION


             ****** PERCENT ARRIVALS TECHNIQUE ******
                    FOR ALL R/W CAPACITY MODELS


ENTER DESIRED % ARRIVALS:    50
ENTER ARRIVAL CAPACITY OF BASIC RUNWAY USE CONFIGURATION:   35
ENTER DEPARTURE CAPACITY OF BASIC RUNWAY USE CONFIGURATION:   25

ENTER ARRIVAL CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL STRE
AMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:   0

ENTER DEPARTURE CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL ST
REAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:   70

PROPORTION OF TIME BASIC RUNWAY USE APPLIES =      .875
PROPORTION OF TIME REVISED RUNWAY USE APPLIES =    .125


                       (OPTION  1)
             *******************************************


             CAPACITY  =      61    OPERATIONS PER HOUR


DO YOU WANT A SENSITIVITY ANALYSIS OF PERCENT ARRIVALS TO CAPACITY?   n


DO YOU WANT TO MAKE ANOTHER CALCULATION?   n
STOP
```

COMPUTER DIALOGUE FOR EXAMPLE 3

FIGURE A-4

APPENDIX B ARRIVAL-ARRIVAL SEPARATION PRE-PROCESSOR

B.1 Introduction

This appendix presents two utility on-line programs that are useful for preparing inputs to the Runway Capacity Model and interpreting inputs used with the Runway Capacity Model. One program will convert observed average separations (i.e., AASR) over the threshold to the model input of minimum separation (i.e., DLTAIJ). The other program will convert the model input of minimum separation into an average separation over the threshold.

Copies of these utility programs are not available for distribution. A listing of each program is contained in paragraph B.6.

B.2 Model Logic

The value of average separation over threshold is related to minimum separation by the equation:

$$AASR(ij) = \frac{DLTA(ij)}{V(j)} - (SIGMA \times fPV) + MAX\left(0,\ G(j) \times \left(\frac{1}{V(j)} - \frac{1}{V(i)}\right)\right)$$

where:

AASR(ij) is the average separation between a pair of arrival aircraft over the threshold.

DLTA(ij) is the input DLTAIJ to the Runway Capacity Model; i.e., the minimum separation over the common approach path between a pair of arrival aircraft.

V(j) is the velocity of the trailing arrival aircraft.
V(i) is the velocity of the lead arrival aircraft.
SIGMA is the standard deviation of arrival-arrival separation.
fPV is the number of standard deviations to be applied to the standard deviation to create a separation buffer which will prevent aircraft from coming closer together than the minimum separation. NOTE: For probabilities less than .50, fPV will be a negative number.
G(j) is the length of the common approach path for the trailing aircraft.

B.3 Input Format

B.3.1 AASR to DLTA

The program to convert average separations over threshold into model inputs DLTAIJ can be called by the command EXECUTE DLTAIJ.SFO. The model will first ask for the average separation between each aircraft pair in nautical miles; i.e.,

```
D(A,A) =
D(A,B) =
D(A,C) =
D(A,D) =
D(B,A) =
D(B,B) =
D(B,C) =
D(B,D) =
D(C,A) =
D(C,B) =
D(C,C) =
D(C,D) =
D(D,A) =
D(D,B) =
D(D,C) =
D(D,D) =
```

After all separations have been input, the model will request values for the length of the common approach path in nautical miles by aircraft class; i.e.,

```
G(A) =
G(B) =
G(C) =
G(D) =
```

After all distances have been input, the model will request the standard deviation of arrival-arrival separation in seconds; i.e.,

```
SIGMA ARR-ARR =
```

Followed by the absolute number of standard deviations you wish to include in the separation buffer; i.e.,

```
F(PROB. OF VIOLATION) =
```

Values of F(PROB. OF VIOLATION) are:

PROB. OF VIOLATION	F(PROB. OF VIOLATION)
.01	-2.35
.02	-2.05
.03	-1.90

.04	-1.75
.05	-1.65
.06	-1.55
.07	-1.45
.08	-1.40
.09	-1.35
.10	-1.30

B.3.2 DLTA to AASR

The program to convert the model input DLTAIJ into the average separation over theshold can be called by the command EXECUTE AASR.SFO. The model will ask the same series of questions shown in paragraph B.3.1. However, the input for D(A,A) through D(D,D) should be the value of DLTAIJ in nautical miles.

B.4 Output

The output of these models is a table listing the values of AASR and DLTAIJ for each aircraft pair.

B.5 Examples

The following example illustrates the use of AASR.SFO and DLTAIJ.SFO.

Example 1

Convert the following matrix of DLTAIJ values to AASR values:

		Trail Aircraft A	B	C	D
Lead Aircraft	A	3	3	3	3
	B	3	3	3	3
	C	4	4	3	3
	D	6	6	5	4

The length of the common approach path is 6 nautical miles for all aircraft classes, SIGMA is 15 seconds and FPV = -1.9.

The computer dialogue for this problem is shown in Figure B-1. The matrix of AASR values is:

		Trail Aircraft A	B	C	D
Lead Aircraft	A	3.8	4.0	4.0	4.1
	B	5.0	4.0	4.0	4.1
	C	6.4	5.4	4.0	4.1
	D	8.7	7.8	6.5	5.1

Example 2

Convert the following matrix of AASR values to DLTAIJ values.

		Trail Aircraft			
		A	B	C	D
	A	3	3	3	3
Lead Aircraft	B	3	3	3	3
	C	4	4	3	3
	D	6	6	5	4

The length of the common approach path is 6 nautical miles for all aircraft classes, SIGMA is 15 seconds, and FPV = -1.9.

The computer dialoque for this problem is shown in Figure B-2. The matrix of DLTAIJ values is:

		Trail Aircraft			
		A	B	C	D
	A	2.2	2.1	2.0	1.9
Lead Aircraft	B	1.0	2.1	2.0	1.9
	C	1.6	2.6	2.0	1.9
	D	3.3	4.2	3.5	2.9

B.6 PROGRAM LISTING

```
type aasr.sfo
DISPLAY'D=AASR,   G=GAMA'
DIMENSION G(4),DIJ(4,4)
REAL IAS
DISPLAY'TO CONVERT AASR INTO DLTAIJ'
ACCEPT 'D(A,A)=',DIJ(1,1),'D(A,B)=',DIJ(1,2),'D(A,C)=',DIJ(1,3),
                                                                  'D(
',DIJ(1,4)
ACCEPT'D(B,A)=',DIJ(2,1),'D(B,B)=',DIJ(2,2),'D(B,C)=',DIJ(2,3),
                                                                  'D(B
,DIJ(2,4)
ACCEPT'D(C,A)=',DIJ(3,1),'D(C,B)=',DIJ(3,2),'D(C,C)=',DIJ(3,3),
                                                                  'D(C
,DIJ(3,4)
ACCEPT'D(D,A)=',DIJ(4,1),'D(D,B)=',DIJ(4,2),'D(D,C)=',DIJ(4,3),
                                                                  'D(D
,DIJ(4,4)
ACCEPT'G(A)=',G(1),'G(B)=',G(2),'G(C)=',G(3),'G(D)=',G(4)
ACCEPT 'SIGMA ARR-ARR=',SAA
ACCEPT'F( PROB. OF VIOLATION)=',FPV
DISPLAY'........................'
96 CONTINUE
97 CONTINUE
98 CONTINUE
DISPLAY 'A=1, B=2, C=3, D=4'
DISPLAY 'M=LEAD AIRCRAFT'
DISPLAY'N= TRAILING AIRCRAFT'
DO 100 M=1,4,1
IF (M.EQ.1)VI=95
IF(M.EQ.2)VI=120
IF(M.EQ.3) VI=130
IF(M.EQ.4) VI=140
15 DO 100 N=1,4,1
IF(N.EQ.1)VJ=95
IF (N.EQ.2)VJ=120
IF(N.EQ.3) VJ=130
IF(N.EQ.4) VJ=140
5 IF(VI.GT.VJ) GOTO 10
GOTO 20
DISPLAY'DDIJ MEANS DLTAIJ.  DIJ IS USED HERE FOR IAS.'
10 DDIJ=DIJ(M,N)+(((G(N)/VI)-(SAA*FPV/3600))*VJ)-G(N)
GOTO 30
20 DDIJ=DIJ(M,N)-(SAA*FPV*VJ/3600)
30 DISPLAY 'M=',M,'N=',N,'FOR AASR=',DIJ(M,N),'DLTAIJ IN N MI=',DDIJ
100 CONTINUE
END
```

```
type dltaij.sfo
      DISPLAY'D=DLTAIJ,  G=GAMA,  '
      DIMENSION G(4),DIJ(4,4)
      REAL IAS
      DISPLAY'TO CONVERT DLTAIJ INTO AASR IN N MI.'
      ACCEPT 'D(A,A)=',DIJ(1,1),'D(A,B)=',DIJ(1,2),'D(A,C)=',DIJ(1,3),'D(A,D)=',DIJ(1,4)
      ACCEPT'D(B,A)=',DIJ(2,1),'D(B,B)=',DIJ(2,2),'D(B,C)=',DIJ(2,3),'D(B,D)=',DIJ(2,4)
      ACCEPT'D(C,A)=',DIJ(3,1),'D(C,B)=',DIJ(3,2),'D(C,C)=',DIJ(3,3),'D(C,D)=',DIJ(3,4)
      ACCEPT'D(D,A)=',DIJ(4,1),'D(D,B)=',DIJ(4,2),'D(D,C)=',DIJ(4,3),'D(D,D)=',DIJ(4,4)
      ACCEPT'G(A)=',G(1),'G(B)=',G(2),'G(C)=',G(3),'G(D)=',G(4)
      ACCEPT 'SIGMA ARR-ARR=',SAA
      ACCEPT'F( PROB. OF VIOLATION)=',FPV
      DISPLAY'........................'
      96 CONTINUE
      97 CONTINUE
      98 CONTINUE
      DISPLAY 'A=1, B=2, C=3, D=4'
      DISPLAY ' '
      DISPLAY'M= LEAD AIRCRAFT.'
      DISPLAY 'N=TRAILING AIRCRAFT.'
      DISPLAY' '
      DISPLAY 106
      DO 100 M=1,4,1
      IF  (M.EQ.1)VI=95

      IF(M.EQ.2) VI=120
      IF(M.EQ.3) VI=130
      IF(M.EQ.4) VI=140
      15 DO 100 N=1,4,1
      IF(N.EQ.1)VJ=95
      IF  (N.EQ.2)VJ=120
      IF(N.EQ.3) VJ=130
      IF(N.EQ.4) VJ=140
      5 IF(VI.GT.VJ) GOTO 10
      GOTO20
      10 IAS=(((G(N)+DIJ(M,N))/VJ)-(G(N)/VI)+(SAA*FPV/3600))*VJ
      GOTO 30
      20 IAS=DIJ(M,N)+(SAA*FPV*VJ/3600)
      30 DISPLAY'M=',M,'N='N,'FOR DLTAIJ=',DIJ(M,N),'AASR IN N MI=',IAS
      100 CONTINUE
      END
```

```
execute dltaij.sfo
SFORTRAN: DLTAIJ
LOADING
EXECUTION
D=DLTAIJ,  G=GAMA,
TO CONVERT DLTAIJ INTO AASR IN N MI.
D(A,A)=3
D(A,B)=3
D(A,C)=3
D(A,D)=3
D(B,A)=3
D(B,B)=3
D(B,C)=3
D(B,D)=3
D(C,A)=4
D(C,B)=4
D(C,C)=3
D(C,D)=3
D(D,A)=6
D(D,B)=6
D(D,C)=5
D(D,D)=4
G(A)=6
G(B)=6
G(C)=6
G(D)=6
SIGMA ARR-ARR=15
F( PROB. OF VIOLATION)=1.9
.........................
A=1, B=2, C=3, D=4

M= LEAD AIRCRAFT.
N=TRAILING AIRCRAFT.

 106
M=    1    N=    1    FOR DLTAIJ=    3    AASR IN N MI=    3.752083
M=    1    N=    2    FOR DLTAIJ=    3    AASR IN N MI=    3.95
M=    1    N=    3    FOR DLTAIJ=    3    AASR IN N MI=    4.029167
M=    1    N=    4    FOR DLTAIJ=    3    AASR IN N MI=    4.108333
M=    2    N=    1    FOR DLTAIJ=    3    AASR IN N MI=    5.002083
M=    2    N=    2    FOR DLTAIJ=    3    AASR IN N MI=    3.95
M=    2    N=    3    FOR DLTAIJ=    3    AASR IN N MI=    4.029167
M=    2    N=    4    FOR DLTAIJ=    3    AASR IN N MI=    4.108333
M=    3    N=    1    FOR DLTAIJ=    4    AASR IN N MI=    6.367468
M=    3    N=    2    FOR DLTAIJ=    4    AASR IN N MI=    5.411538
M=    3    N=    3    FOR DLTAIJ=    3    AASR IN N MI=    4.029167
M=    3    N=    4    FOR DLTAIJ=    3    AASR IN N MI=    4.108333
M=    4    N=    1    FOR DLTAIJ=    6    AASR IN N MI=    8.680655
M=    4    N=    2    FOR DLTAIJ=    6    AASR IN N MI=    7.807143
M=    4    N=    3    FOR DLTAIJ=    5    AASR IN N MI=    6.457738
M=    4    N=    4    FOR DLTAIJ=    4    AASR IN N MI=    5.108333

EXIT
```

COMPUTER DIALOGUE FOR EXAMPLE 1

FIGURE B-1

```
 execute aasr.sfo
SFORTRAN: AASR
LOADING
EXECUTION
D=AASR,   G=GAMA
TO CONVERT AASR INTO DLTAIJ
D(A,A)=3
D(A,B)=3
D(A,C)=3
D(A,D)=3
D(B,A)=3
D(B,B)=3
D(B,C)=3
D(B,D)=3
D(C,A)=4
D(C,B)=4
D(C,C)=3
D(C,D)=3
D(D,A)=6
D(D,B)=6
D(D,C)=5
D(D,D)=4
G(A)=6
G(B)=6
G(C)=6
G(D)=6
SIGMA ARR-ARR=15
F( PROB. OF VIOLATION)=1.9
.........................
A=1, B=2, C=3, D=4
M=LEAD AIRCRAFT
N= TRAILING AIRCRAFT
M=     1    N=    1    FOR AASR=    3    DLTAIJ IN N MI=    2.247917
M=     1    N=    2    FOR AASR=    3    DLTAIJ IN N MI=    2.05
M=     1    N=    3    FOR AASR=    3    DLTAIJ IN N MI=    1.970833
M=     1    N=    4    FOR AASR=    3    DLTAIJ IN N MI=    1.891667
M=     2    N=    1    FOR AASR=    3    DLTAIJ IN N MI=    .9979167
M=     2    N=    2    FOR AASR=    3    DLTAIJ IN N MI=    2.05
M=     2    N=    3    FOR AASR=    3    DLTAIJ IN N MI=    1.970833
M=     2    N=    4    FOR AASR=    3    DLTAIJ IN N MI=    1.891667
M=     3    N=    1    FOR AASR=    4    DLTAIJ IN N MI=    1.632532
M=     3    N=    2    FOR AASR=    4    DLTAIJ IN N MI=    2.588462
M=     3    N=    3    FOR AASR=    3    DLTAIJ IN N MI=    1.970833
M=     3    N=    4    FOR AASR=    3    DLTAIJ IN N MI=    1.891667
M=     4    N=    1    FOR AASR=    6    DLTAIJ IN N MI=    3.319345
M=     4    N=    2    FOR AASR=    6    DLTAIJ IN N MI=    4.192857
M=     4    N=    3    FOR AASR=    5    DLTAIJ IN N MI=    3.542262
M=     4    N=    4    FOR AASR=    4    DLTAIJ IN N MI=    2.891667
```

COMPUTER DIALOGUE FOR EXAMPLE 2

FIGURE B-2

C.1 Introduction

The output of the Taxiway Capacity Model described in Chapter 8 is the capacity of a single exit taxiway crossing a runway. This appendix describes on-line programs for computing:

a) The demand per exit on a series of exit taxiways fed by a runway.

b) The aircraft mix per exit on a series of exit taxiways fed by a runway.

c) The combined capacity of a runway and its exit taxiways.

These programs are for parallel and non-parallel runway use configurations where arrival operations on the outer runway must cross the inner runway to reach the terminal building.

Copies of these on-line programs are not available for distribution. A listing of each program is contained in paragraph C.6.

C.2 Model Logic

The first approximation of demand by aircraft class on a series of exit taxiways fed by a runway (DEAit) is given by:

$$DEAit = RWD \times Mi \times Eit/100$$

where RWD is the feeder runway arrival demand,
Mi is the runway mix by aircraft class,
Eit is the exit utilization percent by aircraft class and exit.

The first approximation of taxiway mix for a series of exit taxiways fed by a runway (MEAit) is given by:

$$MEAit = (DEAit \times 100)/(RWD \times UPt)$$

where $UPt = \sum_{i=1}^{4} Eit \times Mi$

The combined capacity of a runway and its feeder taxiways (CRT) is given by:

$$CRT = \sum_{i=1}^{4} \sum_{t=1}^{N} CAit$$

CAit is the crossing capacity for a given exit taxiway and aircraft class. CAit is determined by:

Let DAit be the exit taxiway demand by aircraft class.

$$DAit = Dt \times Mit$$

where Dt is the demand by taxiway,
Mit is the aircraft mix by taxiway

$$CAit = Dt \times Mit \text{ if } DAit \text{ is less than } Ct \times Mit$$

$$CAit = Ct \times Mit \text{ if } DAit \text{ is equal to or greater than } Ct \times Mit$$

in which case $DAiu = DAiu + (DAit - (Ct \times Mit))$

where Ct is the crossing capacity of a given taxiway and $u = t + 1$

The final value of demand per exit is obtained by summing the values of CAit for each exit. The final value of mix per exit is obtained by dividing the values of CAit by the demand per exit.

C.3 Input Format

Two on-line programs are required to obtain the aircraft mix per exit and aircraft demand per exit; i.e.,

a) TWUTIL

b) TWCAP

The output of TWUTIL supplies the first approximation of aircraft mix per exit taxiway, the first approximation of demand per exit taxiway, and values of TW VEL, AC SIZE, RWCLR, and HEADWAY needed to calculate the capacity of an individual taxiway. The values of crossing capacity, demand per exit and mix per exit become inputs to TWCAP which calculates the desired parameters.

C.3.1 TWUTIL

The program to calculate the first approximation of the demand by aircraft class on a series of exit taxiways and the aircraft mix is called by the command EXECUTE TWUTIL.SFO. The questions asked by the program are:

ENTER THE NUMBER OF TAXIWAYS:

Any integer between 1 and 10 may be entered.

ENTER THE EXIT UTILIZATION PERCENT FOR EXIT 1 BY AIRCRAFT CLASS (A, B, C, D):

Four integer numbers between 0 and 100 which sum to 100 are required. The first number is for class A aircraft. The last number is for class D aircraft. The individual exit utilizations can be determined by using the cumulative exit utilization table shown in Table 2-3. The model assumes exits are in ascending numerical order from the threshold. This question is repeated for each exit.

ENTER RUNWAY MIX (A, B, C, D):

Four integer numbers between 0 and 100 which sum to 100 are required.

ENTER RUNWAY ARRIVAL DEMAND:

Any integer between 1 and 100 may be entered. Enter the runway capacity if the resultant flow rate is to be considered as the combined capacity of the runway and exit taxiway system. Enter the expected runway demand if the resultant flow rate is to be used in the calculation of delay.

TAXI VELOCITY BY AIRCRAFT TYPE:
AIRCRAFT SIZE FOR EACH AIRCRAFT TYPE:
RUNWAY CROSSING DISTANCE BY AIRCRAFT TYPE:
HEADWAY BY AIRCRAFT TYPE:

Each question requires four integer numbers. The first is for aircraft class A. The last is for aircraft class D.

C.3.2 TWCAP

The program to calculate the final demand per exit, mix per exit and combined capacity of a runway and exit taxiway system is called by the command EXECUTE TWCAP.SFO. The questions asked by the program are:

ENTER THE NUMBER OF TAXIWAYS:

Any integer between 1 and 10 may be entered.

The following three questions are repeated for each taxiway:

AIRCRAFT MIX (A, B, C, D):

Four integer numbers between 0 and 100 which sum to 100 are required. The first is for class A aircraft. The last is for class D aircraft. This input is determined by running the program TWUTIL. This question will be repeated for each taxiway.

AIRCRAFT DEMAND:

Enter the total demand on the given exit. This input is first determined by running the program TWUTIL.

This question will be repeated for each exit taxiway.

TAXIWAY CROSSING CAPACITY:

Any number between 0.0 and 100.0 may be entered. This input is determined by the taxiway crossing model described in Chapter 8. This question will be repeated for each exit taxiway.

C.4 Output

C.4.1 TWUTIL

The output of the program TWUTIL consists of:

a) The aircraft mix for each exit (assuming that crossing capacity does not limit use of the exit); i.e.,

```
                AIRCRAFT MIX BY EXIT
                    %A     %B     %C     %D
EXIT 1
EXIT 2
EXIT 3
   .
   .
   .
EXIT 10
```

b) The aircraft demand for each exit (assuming that crossing capacity does not limit use of the exit); i.e.,

```
                AIRCRAFT DEMAND BY EXIT
                    A      B      C      D
EXIT 1
EXIT 2
EXIT 3
   .
   .
   .
EXIT 10
```

TAXIWAY CAPACITY MODEL INPUTS

	Taxiway Velocity	Aircraft Size	Crossing ClLength	Headway
EXIT 1				
EXIT 2				
EXIT 3				
.				
.				
.				
EXIT 10				

Following the printing of the output, it is possible to compute exit demand and mix using other values of runway mix and arrival demand.

DO YOU WANT TO MAKE ANOTHER CALCULATION USING THE SAME EXIT UTILIZATION PERCENTS?

A Y or YES response will result in the question:

ENTER RUNWAY MIX:

A N or NO response will result in the question:

DO YOU WANT TO MAKE ANOTHER CALCULATION?

A Y or YES response will result in the question:

ENTER THE NUMBER OF TAXIWAYS:

A N or NO response will terminate the program.

C.4.2 TWCAP

The output of the program TWCAP consists of:

a) The flow rate on each exit; i.e.,

	EXIT FLOW RATE
EXIT 1	
EXIT 2	
EXIT 3	
.	
.	
.	
EXIT 10	
TOTAL	

If the input demand by aircraft class is equal to capacity on the runway, the output total flow rate on the exit system can be regarded as the combined capacity of the runway and exit taxiway system. If the input demand by aircraft class is the

expected demand on the runway, the individual exit flow rates can be used as demand in the demand divided by capacity ratio for calculating average delay per aircraft.

b) The mix on each exit; i.e.,

MIX BY EXIT

	A	B	C	D
EXIT 1				
EXIT 2				
EXIT 3				
.				
.				
.				
EXIT 10				

If the combined capacity of the runway and exit taxiway systems is less than the runway capacity as calculated from Chapter 2, the ability to cross aircraft limits the capacity of the runway.

Following the printing of the output, the program will terminate.

C.5 Examples

The following illustrates the use of the on-line program to compute runway-taxiway capacity.

Example 1

Compute the aircraft mix and aircraft demand on each exit taxiway for the following conditions:

Runway 15R Demand = Runway Capacity = 50 operations/hr.
Percent Arrival = 50
Aircraft Mix: A = 10%
B = 20%
C = 30%
D = 40%

Aircraft Type	Taxiway Velocity	Aircraft Size	Runway Clearance	Headway
A	10	28	350	350
B	10	50	350	350
C	15	150	450	750
D	15	200	450	750

EXIT	LOCATION
1	1000 feet from threshold
2	3000 feet " "
3	4000 feet " "
4	5000 feet " "
5	6000 feet " "
6	8000 feet " "

From Table 2-3, the following exit utilization percents are obtained:

EXIT	LOCATION	EXIT PERCENT A	B	C	D
1	1000	6	0	0	0
2	3000	94	39	0	0
3	4000	-	59	8	0
4	5000	-	2	41	9
5	6000	-	-	43	62
6	8000	-	-	8	29

The computer dialogue for this problem is shown in Figure C-1. The results are:

EXIT	LOCATION	Aircraft Mix A	B	C	D	Demand
1	1000	100	0	0	0	1
2	3000	55	45	0	0	4
3	4000	0	83	17	0	3
4	5000	0	3	75	22	4
5	6000	0	0	34	66	9
6	8000	0	0	17	83	4

Example 2

If the arrival operations on runway 15R in example 1 have to cross runway 15L to get to the terminal area, what is the maximum aircraft demand that can operate on runway 15R if the demand on runway 15L is fixed at 58 operations per hour?

The Taxiway Capacity Model was used to calculate the crossing capacity of each exit. The results were:

EXIT	LOCATION	Crossing Capacity
1	1000	30
2	3000	22
3	4000	13
4	5000	6
5	6000	4
6	8000	3

The computer dialogue for this problem is shown in Figure C-2. The combined capacity of runway 15R and its exit taxiway system is found to be 38 (i.e., 19 x 2) operations per hour. The exit taxiway system limits the capacity of runway 15R in this example.

C.6 Program Listing

type twutil.sfo

```
DIMENSION E(4,10),M(4),UP(10),D(4),DE(10),DEA(4,10),MEA(4,10)
DIMENSION TV(4),AS(4),RC(4),H(4),ATV(10),AAS(10),ARC(10),AH(10)
STRING Q1(3),Q2(3)
INTEGER T
REAL M,MEA
5 ACCEPT 'ENTER THE NUMBER OF TAXIWAYS:  ',N
DISPLAY ' '
DO 10 T=1,N,1
DISPLAY 'ENTER THE EXIT UTILIZATION PERCENT FOR EXIT ',T
ACCEPT  'BY AIRCRAFT CLASS (A,B,C,D):  ',E(1,T),E(2,T),

                  E(3,T),E(4,T)
DISPLAY ' '
10 CONTINUE
ACCEPT'ENTER RUNWAY MIX (A,B,C,D:  ',M(1),M(2),M(3),M(4)
ACCEPT 'ENTER RUNWAY ARRIVAL DEMAND:  ',RWD
ACCEPT 'TAXI VELOCITY BY AIRCRAFT TYPE:  ',TV(1),TV(2),TV(3),TV(4)
ACCEPT'AIRCRAFT SIZE FOR EACH AIRCRAFT TYPE:  ',
                                                       AS(1),AS(2),AS(3),AS(4)
ACCEPT'RUNWAY CLEARACNE BY AIRCRAFT TYPE:  ',RC(1),RC(2),RC(3),RC(4)
ACCEPT'HEADWAY BY AIRCRAFT TYPE:  ',H(1),H(2),H(3),H(4)
Z=0
DO 30 T=1,N,1
DO 20 I=1,4,1
20 Z=E(I,T)*M(I)/10000.0+Z
UP(T)=Z
Z=0
30 CONTINUE
DO 40 I=1,4,1
D(I)=RWD*M(I)/100.0
40 CONTINUE
DO 50 T=1,N,1
DE(T)=RWD*UP(T)
 50 CONTINUE
DO 60 T=1,N,1
DO 60 I=1,4,1
DEA(I,T)=D(I)*E(I,T)/100.0
MEA(I,T)=DEA(I,T)/DE(T)*100.0
60 CONTINUE
DISPLAY'-----------------------------------------'
DISPLAY' '
DISPLAY'         AIRCRAFT MIX BY EXIT'
DISPLAY'                  A        B        C        D'
DO 80 T=1,N,1
WRITE(1,70) T,MEA(1,T),MEA(2,T),MEA(3,T),MEA(4,T)
70 FORMAT (4X,5HEXIT ,I1,3X,4F7.1)
80 CONTINUE
DISPLAY' '
DISPLAY' '
```

```
DISPLAY'                      AIRCRAFT DEMAND BY EXIT'
DISPLAY'                        A        B        C        D'
DO 100 T=1,N,1
WRITE(1,90) T,DEA(1,T),DEA(2,T),DEA(3,T),DEA(4,T)
90 FORMAT(4X,5HEXIT ,I1,4F7.1)
100 CONTINUE
DO 110 T=1,N,1
ATV(T)=0
AAS(T)= 0
ARC(T)=0
AH(T)=0
DO 110 I=1,4,1
ATV(T)=ATV(T)+TV(I)*MEA(I,T)/100.0
AAS(T)=AAS(T)+AS(I)*MEA(I,T)/100.0
ARC(T)=ARC(T)+RC(I)*MEA(I,T)/100.0
AH(T)=AH(T)+H(I)*MEA(I,T)/100.0
110 CONTINUE
DISPLAY' '
DISPLAY' '
DISPLAY'                      TAXIWAY CAPACITY MODEL INPUTS'
DISPLAY'                 TW VEL      AC SIZE      RW CLR      HEADWAY'
DO 120 T=1,N,1
WRITE(1,121) T,ATV(T),AAS(T),ARC(T),AH(T)
121 FORMAT(5HEXIT ,I1,5X,F6.0,5X,F7.0,5X,F6.0,5X,F7.0)
120 CONTINUE
ACCEPT'DO YOU WANT TO MAKE ANOTHER RUN USING THE SAME EXIT UTILIZATION P
**ERCENTS? ',Q1
IF(Q1.EQ.'Y'.OR.Q1.EQ.'YWS') GOTO 10
ACCEPT'DO YOU WANT TO MAKE ANOTHER CALCULATION? ',Q2
IF(Q2.EQ.'Y'.OR.Q2.EQ.'YES') GOTO 5
END
```

```
type twcap.sfo
      DIMENSION M(4,10),D(10),C(10),CA(4,10),DA(4,10)
      DIMENSION RDA(4,10)
      REAL M
      INTEGER T
      ACCEPT 'ENTER THE NUMBER OF TAXIWAYS:  ',N
      DISPLAY ' '
      DO 5 T=1,N,1
      DISPLAY 'FOR TAXIWAY',T
      ACCEPT 'AIRCRAFT MIX(A,B,C,D):  ',M(1,T),M(2,T),M(3,T),M(4,T)
      ACCEPT 'AIRCRAFT DEMAND:  ',D(T)
      ACCEPT 'TAXIWAY CROSSING CAPACITY:  ',C(T)
      DISPLAY' '
      5 CONTINUE
      TD=0
      DO 1 T=1,N,1
      TD=TD+D(T)
      1 CONTINUE
      C(N+1)=1
      DO 10 T=1,N,1
      DO 10 I=1,4,1
      CA(I,T)=C(T)*M(I,T)/100.0
      DA(I,T)=D(T)*M(I,T)/100.0
      10 CONTINUE
      DO 20 T=1,N,1
      IF(D(T).LT.C(T)) C(T)=D(T)
      IF(D(T).GE.C(T)) C(T)=C(T)
      IF(D(T).GT.C(T))D(T+1)=D(T+1)+(D(T)-C(T))
      20 CONTINUE
      DO 30 T=1,N,1
      DO 30 I=1,4,1
      IF(D(T).LE.C(T)) R=0
      IF (D(T).LE.C(T)) GOTO 30
      IF(D(T).GT.C(T)) R=D(T)-C(T)
      RDA(I,T+1)=R*M(I,T)/100.0+DA(I,T+1 )
      M(I,T+1)=RDA(I,T+1)/D(T+1)*100.0
      R=0
      30 CONTINUE
      CRT=0
      DO 40 T=1,N,1
      CRT=CRT+C(T)
      40 CONTINUE
      DISPLAY' '
      DISPLAY' -------------------------------------------'
      IF(TD.GT.CRT)  DISPLAY'THE RUNWAY/TAXIWAY SYSTEM IS GOVERNED
                                                            BY THE TAXI
WAY CROSSING CAPACITY'
      IF(TD.LE.CRT) DISPLAY'THE RUNWAY /TAXIWAY SYSTEM IS GOVERNED BY THE RUN
**WAY CAPACITY'
      DISPLAY' '
      DISPLAY'THE COMBINED CAPACITY OF A RUNWAY AND SYSTEM OF FEEDER TAXIWAYS
**IS',CRT,'OPERATIONS PER HOUR.'
      DISPLAY 'THE DEMAND ON EACH EXIT IS:'
      DO 70 T=1,N,1
```

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SUPPLEMENTARY
INFORMATION

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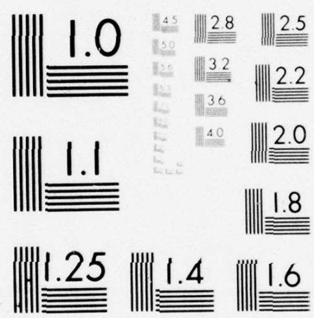

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SUPPLEMENTARY

INFORMATION

ADDENDUM

Report No. FAA-RD-76-128
Book 1

MODEL USERS' MANUAL FOR AIRFIELD CAPACITY AND DELAY MODELS

Introduction

Book 1 of "Model Users' Manual for Airfield Capacity and Delay Models" FAA-RD-76-128 was released in November 1976. User experience over the last 6 months has resulted in changes and additions to several of the models contained in that report; i.e., Delay Simulation Model, On-line Annual Delay Model and Batch Annual Delay Model. This document updates the user instructions contained in the Model Users' Manual, Book 1.

Text Changes

Delete and add new pages:

- 9/10, 11/12, 13/14
- 101/102, 103/104, 109/110, 111/112, 113/114, 115/116, 123/124, 125/126
- 165/166, 169/170, 171/172
- 189/190

Text Additions

- 91/92
- 126a
- 160a
- 182a through 182m

Release April 22, 1977

o. Batch Capacity Model. The expression "Batch Capacity Model" is used to refer to all runway capacity models plus the taxiway and gate models. It is called "batch" because inputs to the model are normally made on IBM cards via a card reader.

p. Runway Capacity Model. The expression "runway capacity model" is used to refer to all models that compute hourly runway capacity; i.e., single runway model, two parallel runway model, two intersecting runway model, etc.

q. On-line Model. This expression describes the process of using a teletype timesharing terminal with a computer generated question and answer tutorial program.

1.4 Model Overview

The FAA has developed a series of computer models for the analysis of the airside of an airport. These models can be used to determine the capacity and delay on airports, and to study the fine-grain sensitivity of capacity and delay to variations of airport specific conditions.

Two types of models are available:

a. Analytic Models; i.e., closed form equations.

b. A Critical Event Simulation Model; i.e., a computer representation of time ordered events.

Analytic models were developed to determine the hourly capacity of individual airfield components--the runways, the taxiways and the gates. Capacity submodels were developed for over 100 runway use configurations. One model was developed for determining the hourly capacity of a taxiway crossing a runway. One model was developed for estimating gate capacity. These models calculate capacity as the inverse of the average service time for all aircraft being served. For example, if it takes an average of 45 seconds for aircraft to be "served" on a runway, the capacity of the runway equals one aircraft operation per 45 seconds, or 80 operations per hour. These models treat runways, taxiways, and gates as independent elements.

Analytic models have also been developed for determining Annual Service Volume and Annual Delay. The Annual Service Volume Model computes the product of the weighted average hourly capacity, hourly peaking factor and daily peaking factor. The Annual Delay Model computes delay for each representative hour of the year and produces a weighted average annual delay per operation based on input values of weather and capacity distributions.

The Delay Simulation Model was developed to determine delay per aircraft, travel time, and flow rate information. The model simulates the movement of aircraft from the entry gate of the common approach path to the apron gates, and from the apron gates to takeoff. It treats the airfield components as integrated parts of a system. It is a critical events model that employs Monte Carlo sampling techniques. Because of the modular structure of the model, the total airfield or its individual components can be analyzed by manipulation of the model inputs.

Both the Batch Capacity Model and the Delay Simulation Model can be used to analyze the capacity of an airport. Figure 1-3 provides an overview comparison the model logic for the Batch Capacity Model and the Delay Simulation Model. Generally, the Delay Simulation Model is more versatile, provides more input detail, and is more system oriented than the Batch Capacity Model. However, substantially more time is required to develop inputs for the Delay Simulation Model and much greater computer capacity is required.

On-line models were developed to work in conjunction with the Batch Capacity Model, Annual Delay Model and to compute Annual Service Volume. The On-line Runway Capacity Model is a tutorial program with stored data that accesses the Batch Capacity Model to compute capacity. The model logic (i.e., equations) for the On-line Runway Capacity Model and the Batch Capacity Model are identical. The On-line Annual Delay Model is a special adaptation of the Annual Delay Model. The full input capability of the Annual Delay Model is available through the On-line Annual Delay Model. However, the distributions of capacity, demand and weather are in fixed intervals; i.e., monthly, daily, hourly, VFR, IFR and PVC. As an option, stored data can be called for some parameters. The Annual Service Volume Model is only available in a tutorial on-line model. No built in data is available.

1.5 Model Availability

The models described in this report are available for airport planning. A magnetic tape containing the Batch Capacity Model, Delay Simulation Model, On-line Annual Delay Model, Batch Annual Delay Model and the Routing Data Pre-Processor for the Delay Simulation Model along with example problems may be purchased from:

National Technical Information Service
Attn: Order Desk
5285 Port Royal Road
Springfield, VA 22161

The program name is: FAA Airport Capacity and Delay Models (Report No. FAA-RD-77-45, dated April 1977). Magnetic tapes are available in 9 track, 800 bpi recording modes.

In addition, copies of this magnetic tape may be borrowed from:

Chief, Airport Design Branch, ARD-410
DOT/FAA
2100 Second Street, S.W.
Washington, D.C. 20950

(202) 426-3685

on an "as available" basis.

1.6 Configuration Control

Configuration control is being exercised by the FAA over the models contained in this report. This is for the purpose of documenting changes and extending model capabilities. The following are valid programs as of April 1977:

Batch Capacity Model Version 5a
Delay Simulation Model Version 2f
Batch Annual Delay Model Version 1b
On-line Runway Capacity Model Version 2
On-line Annual Service Volume Model Version 1
On-line Annual Delay Model Version 1 (Jan.1977)

1.7 Computer Requirements

All the computer programs referenced in this report are written in a basic form of FORTRAN IV and should be readily useable on any FORTRAN compatible computer. The following table defines the approximate core requirements for each program.

Model	Core Requirement
Batch Capacity Model Version 5	210k bytes
Delay Simulation Model 3	490k bytes
Annual Delay Version 1	30k (octal) on CDC CYBER 74

1.8 References

a. Procedures for Determination of Airport Capacity, FAA-RD-73-111, Volumes I and II, April 1973, Interim Report, Phase I

This report discusses:

(1) The results of a user survey on what an airport capacity/delay determination report should contain.

(2) The data collection effort conducted in the Fall of 1972.

(3) The model logic concepts for the analytical capacity model.

(4) The model logic concepts for the Delay Simulaticn Model.

b. Techniques for Determining Airport Capacity and Delay, FAA-RD-74-124, dated June 1976

This report discusses:

(1) An hourly capacity determination procedure via curves.

(2) An approximate hourly delay determination procedure via curves.

(3) The tutorial computer programs for determining runway capacity and annual delay discussed in this report.

(4) Manual calculation of Annual Service Volume.

c. Technical Report on Airport Capacity and Delay Studies, FAA-RD-76-153 dated June 1976

This report discusses:

(1) Capacity and simulation model logic.

(2) The validation of the capacity and simulation model.

(3) Issues related to the production of simplified capacity and delay curves.

d. Supporting Documentation for Technical Report on Airport Capacity and Delay Studies, FAA-RD-76-162, dated June 1976

This report discusses:

(1) Runway Capacity Model inputs for O'Hare validation.

(2) Capacity Model inputs for handbook production.

(3) Description of inputs for the On-line Runway Capacity Model.

(4) Description of inputs for the On-line Annual Delay Model.

e. A Model of the Airfield Surface System, D. Maddison, ITTE, University of California, Berkeley, April 1970

f. FAA Technical Reports of Airport Capacity and Aircraft Delay, A/C 150/5060-

This Advisory Circular announces the availability of the models described in this Model Users' Manual for airport planning. It states that these models may be used as an alternative to "Airport Capacity Criteria Used in Preparing the National Airport Plan" A/C 150 5060-1A ("red book") to compute Airport Capacity and Delay for the Planning Grant Program (PGP) and Airport Development Aid Program (ADAP).

Aircraft Classification	Types of Aircraft
Class A	Small single-engine aircraft weighing 12,500 lbs. or less (e.g., PA18, PA23, C180, C207)
Class B	Small twin-engine aircraft weighing 12,500 lbs. or less and Lear jets (e.g., BE31, BE55, BE80, BE99, C310, C402, LR25)
Class C	Large aircraft weighing more than 12,500 lbs. and up to 300,000 lbs. (e.g., CV34, CV58, CV88, CV99, DC4, DC6, DC7, L188, L49, DC8-10, 20 series, DC9, B737, B727, B720, B707-120, BA11, S210)
Class D	Heavy aircraft weighing more than 300,000 lbs. (e.g., L1011; DC8-30, 40 50, 60 series; DC10; B707-300 series; B747; VC10; A300; Concorde; IL62)

---

a. For aircraft type designation, see FAA Order No. 7340.1E with changes.

b. Weights refer to maximum certificated gross take-off weight.

c. Heavy Jet aircraft are capable of 300,000 pounds or more whether or not they are operating at this weight during a particular phase of flight. (Reference: FAA Handbook 7110.8D with changes.)

NOTE: These aircraft classifications generally follow the TERPS categorization. It does not follow the previous categorization used in AC150/5060-1A "Airport Capacity Criteria Used in Preparing the National Airport Plan"; i.e., the "red book."

FIGURE 1-1

AIRCRAFT CLASSIFICATION

For single and dependent runways, priority between arrival operations for use of the common approach path is determined by their event time (minute and hundreth of a minute). The event time is the sum of the input schedule arrival time and delay imposed from other aircraft.

The Delay Simulation Model will permit simultaneous arrivals on close spaced parallel runways unless a small or large aircraft trails a heavy aircraft. In this case, the small or large aircraft is sequenced behind the heavy aircraft with a separation assigned by the model inputs that reflect wake turbulence separation.

Departures have second priority for use of the runways. Before a departure is permitted to occupy the runway and take off, the following checks are made:

a. The runway is not occupied by an arrival or previous departure.

b. The specified separation exists between the departure and the next arrival on the takeoff or dependent runway.

c. The specified separation exists between the departure and the previous departure on the takeoff or dependent runway.

For dependent runways, priority between departure operations for use of the runways is determined by the time they arrive at the departure end link and by conformance with the specified air traffic control separations. For example, if a departure on one runway cannot be cleared because of air traffic control separations, the model checks to see if a departure on the dependent runway could be cleared.

Runway crossings have the lowest priority for use of the runway. A runway crossing can occur if:

a. The runway is not occupied by an arrival or departure.

b. No departures are waiting to use the runway.

c. The aircraft can cross the runway before the arrival comes over the threshold.

The model will permit multiple aircraft to cross the runway between arrival or departure operations. If a runway is operating at capacity, it will be very difficult to cross the runway. The arrival or departure must be clear of the runway before the taxiing aircraft can cross the runway.

4.2.4 Aircraft Descriptions

Four classes (or types) of aircraft can be identified with the Delay Simulation Model. A recommended set is:

Type Number	Class Letter	Description
1	D	Heavy jet; B747, DC10, L1011, DC8-61, B707-3
2	C	Large aircraft; B727, B737, DC-9, CV58
3	B	Small twin-engine aircraft; BE99, LR25
4	A	Small single-engine aircraft; C150, BE23

Aircraft are identified to the model by their type number.

In general, any definition of aircraft classes is possible subject to the constraint that:

type 1 aircraft are larger than type 2,
type 2 aircraft are larger than type 3, and
type 3 aircraft are larger than type 4,

This condition is necessary for the gate logic where it is assumed that an aircraft can use a gate for its type number or of a lower type number.

While an aircraft is being moved within the model, it is assigned a status as listed below.

Aircraft State Number	Description
0	Not Arrived
1	Queued
2	On Way to Gate
3	In Gate
4	On Way to Takeoff
5	Taken Off
6	In Pushback from Gate to Takeoff
7	In Holding Area
8	In Pushback from Holding Area to Gate

4.2.5 Schedule of Operations (i.e., Aircraft Demand)

The schedule data consists of:

airline code
aircraft type
scheduled arrival time at threshold
scheduled departure time from gate
preferred gate
arrival and departure runways

The scheduled arrival times used by the model are arrival times at the threshold. The input arrival time should take into account the desired arrival time as reflected in the Official Airline Guide (OAG) and delays due to originating airport and enroute airspace. These perturbations from the scheduled arrival time at threshold can be incorporated by applying a "lateness distribution" to the desired arrival times.

The scheduled arrival times do not include delays due to airfield congestion. The time at which an arrival is observed to cross the threshold in actual operation includes delay due to airfield congestion and therefore differs from scheduled arrival time.

The runway use strategy is determined by the designation of arrival and departure runways. For multiple runway geometries, the user should make an effort to decide which runway an operation would use based on the origin or destination of the aircraft.

General aviation aircraft do not follow fixed arrival or departure schedules. One approach in determining when to schedule general aviation demand during an hour is to randomly distribute the general aviation demand over the hour in accordance with a standard probability function.

At the beginning of each run, the model assumes that no aircraft are on the airfield. Traffic begins to build up on the airfield according to the aircraft schedule. It is recommended that at least the first hour of a run be used to impose an initial load on the airfield system.

4.2.6 Airport Geometry

The geometry of the airport is entered into the model in the form of a series of numbers from a "link-node diagram." Figure 4-1a illustrates an airfield geometry containing two parallel runways. Figure 4-1b is a link-node diagram developed from this geometry. The technique is to break the taxiway network into a series of numbered links. Link length should not be shorter than the length of the largest aircraft using the taxiway. The link-node diagram assists in defining paths from runway to gates or holding areas, and from gates to runways.

The following relates to the development of a link-node diagram:

a. The model treats an active runway as a single link. Runways that are only used as taxiways can be divided into links.

b. A runway can only have one departure end link.

c. Runway exits cannot be defined as departure end links. (If they are, the arrival will land, exit and immediately take off.)

d. Even if identifiable holding areas (or penalty boxes) do not physically exist on the airport, some provision should be made for holding areas on the airfield in the link-node diagram. This would account for the ability to hold aircraft on taxiways.

e. Two basic kinds of taxiway intersections can be modeled; i.e., Y and link-node. A Y intersection is one at which all the links coming into the intersection are directional. This is illustrated in Figure 4-2(a). A link-node intersection allows opposing traffic to approach the intersection and continuing in a common direction. A link-

Approach Speed
Touch-and-Go Runway Occupancy Time

Exit taxiways are selected according to an input empirical distribution of exit utilization percent by aircraft class. This distribution defines the percent of each aircraft class that will use each exit.

Values for the following parameters are considered to be equal to the mean value:

Length of Common Approach Path
Arrival Runway Occupancy Time Per Exit
Taxiway Velocity

4.3 Input Format

The following general instructions apply to preparing inputs to the Delay Simulation Model:

1. Data entry requires two or more cards depending on data type; i.e.,

   Header Card; e.g., TITLE
   Data Card(s); e.g., LAX DELAY ANALYSIS.

2. The header cards have to be exactly as given on the coding form.

3. There is no fixed sequence for groups of header/ data cards except that:

   RWY NO. OF must precede RWY NAMES and RWY END LINKS

   AIRLINE NAMES must precede AIRLINE GATES

   A/C SCHEDULE must precede A/C SERVICE TIMES, A/C APPROACH SPEEDS and AIRLINE NAMES

4. Multiple runs can be made with one stack of cards. Place replacement header/data cards after the COMPUTE card for the first run.

5. Normally, the user will specify FA (or FALSE) for print options 1, 2 and 3. Print option 4 has been set as TRUE in the model code. It is recommended that print option 5 be entered as FA (or FALSE). If print option 5 is TR, the model will stop if two aircraft meet nose-to-nose on a taxiway. If print option 5 is FA, the model will print a warning message if this situation occurs and allow the run to complete. Print option 6 should be

entered as FA unless detailed queue information is desired.

The normal model outputs (delay, travel time and flow rate statistics) are automatically printed for every run.

6. The model will first try to assign an aircraft to its preferred gate. If that gate is occupied, it will try to assign the aircraft to a gate of the appropriate airline that can accommodate the aircraft size. Since class C aircraft can use gates for C or D type aircraft, it is advisable to enter the gate numbers on the AIRLINE GATES card in the order of those used only by large aircraft; i.e., those used by class C and class D aircraft, followed by those used (only) by class D aircraft. The same gate can be assigned to two or more airlines. However, only one aircraft can occupy a given gate.

7. The model as programmed in Version 2 accommodates up to the following array sizes. The array sizes can easily be increased in the program DIMENSION statements if more flexibility is required.

   a) four active runways

   b) four aircraft types

   c) 19 airlines

   d) Simulated run times of 24 hours

   e) 599 links

   f) 1400 paths

   g) 28,000 items in path descriptions

   h) 20 one-way paths

   i) 25 links in any one-way path

   j) 10 general aviation gate areas

   k) 19 gates per airline

   l) 4 holding areas

   m) 10 runway crossing links

   n) 200 runway exits

   o) 10 random number seeds per run

8. Routing Path Data:

a) Routes are required from:

exits to gates
exits to basing areas
exits to holding areas
holding areas to gates
gates to departure end links
basing areas to departure end links

b) Taxiway routes are defined as a series of connecting links. Links can be of any length. Usually, the length of a link is determined such that: (1) it can hold the longest aircraft expected to use the route, and (2) the sum of the link lengths equals the length of the taxiway section.

c) A runway is not divided into links.

d) A runway can only have one departure end link. Departure end links are associated with runways by the sequence in which they are entered on the RUNWAY END LINKS card; i.e., the end link in cc 1-8 is assigned to Runway 1, cc 9-16 is assigned to Runway 2, etc.

e) A departure end link cannot also be an exit link.

f) Multiple aircraft can be parked in one holding area. Holding areas are assigned by runway. The first holding area is assigned to the first runway, the second holding area is assigned to the second runway, etc. All aircraft can use a common holding area, if desired, by assigning each runway to the same holding area.

g) Do not enter two gate links on a route; e.g., if links 1 and 6 are defined as gates, do not enter a route like 100 99 98 20 19 6 18 17 1.

h) A runway crossing link is the link just before the runway to be crossed. The link that crosses the runway should be long enough to insure adequate clearance before and after the aircraft crosses the runway.

i) Link numbers can only range from 1 to 600.

9. One-way Path Data:

a) A link can be part of many one-way paths.

b) A series of links in a path can be determined to be non-directional if they are used in another path in reverse order;

e.g., if Path 10 consisted of links 1 2 20 21 22 203 and path 57 consisted of links 206 25 24 23 22 21 20 99 100, links 20 21 22 are non-directional. Further analysis may be necessary to determine the comple_e set of non-directional link#s on this taxiway.

c) If a series of links are found to be non-directional (see above), two one-way paths are required unless the series of links is the taxiway feeding a series of gates. For example, if links 20 21 22 23 24 and 25 are found to be a continuous set of non-directional links, the required one-way paths are:

20 21 22 23 24 25 and
25 24 23 22 21 20

If a series of non-directional links is the taxiway feeding a series of gates, a one-way path is required from the entrance to the end of the one-way path. This one-way path will serve as the pushback one-way path for each gate.

d) Aircraft may not enter or exit the middle of a one-way path except to enter or push-back from a gate. If a one-way path serves a series of gates, aircraft can only enter the one-way path at one end. Examples of one-way path geometry and input data are shown in Figure 4-4.

e) A series of links that form a one-way path cannot be input as two or more one-way paths to avoid the 25 link limit on the number of links composing a one-way path.

10. Schedule Data:

a) All departures which originate at a gate should be scheduled at the beginning of the run time. Otherwise, the situation can exist whereby two departures may be occupying the same gate, or an arrival may not be able to occupy the gate reserved for it upon landing which would result in a taxiway lane being permanently blocked. A way to get around this, if it is necessary to have a departure originate at a gate, is to first schedule the operation as an arrival on a pseudo runway and assign it the desired departure time.

b) Arrival and departure times are required for through flights; i.e., those which arrive, occupy the gate and depart. If a departure time is not given, the model will select a departure time based on the gate occupancy time.

c) Enter the basing area number as the preferred gate of a general aviation arrival aircraft. General aviation arrivals have no departure time.

d) General aviation departures have no arrival time.

e) Touch-and-go operations require an arrival time but no departure time. Enter 0 for preferred gate.

11. Aircraft Separation:

a) A set of aircraft separation matrices are required for a single runway and for all dependent runway pairs.

b) Each set of aircraft separation matrices may consist of individual matrices for:

Arrival-Arrival Separation in nautical miles

Departure-Departure Separation in minutes

Departure-Arrival Separation in nautical miles

Arrival-Departure Separation in minutes

c) Each matrix contains separation values (i.e., mean and standard deviation) for given lead and trail aircraft type pairs; i.e., up to 16 pairs of separation values.

d) Only those elements in a separation matrix that are required by the schedule data need be input. For example, if no type 1 aircraft were in the schedule, no separations involving type 1 aircraft need be entered.

e) Only those separation matrices required by the schedule data need be input. For example, if all arrival operations are on Runway 1 and all departure operations on Runway 2 and Runways 1 and 2 are dependent, departure-arrival separation values for Runway 2 on Runway 1 are required but arrival-arrival, departure-departure and arrival-departure separations for

Runway 1 on Runway 2 and Runway 2 on Runway 1 as well as the departure-arrival separation for Runway 1 on Runway 2 are not required. The full set of separation matrices for a single runway would be required.

f) Separation matrices for a single runway should be entered as Runway 1 on Runway 1. This set of matrices is used for all single runways. Therefore, separation matrices for Runway 2 on Runway 2, Runway 3 on Runway 3, etc., are not required.

g) The input arrival-arrival separation by aircraft pair SEPAR(I,J) can be determined from observed separations over threshold as follows:

IF VI   VJ:
SEPAR(I,J) = OTS (I,J) x VJ/60

IF VI   VJ:
SEPAR(I,J) = OTS (I,J) - (60 x GJ x FV)

where
VI = velocity of lead arrival in nautical miles
VJ = velocity of trailing arrival in nautical miles
OTS (I,J) = observed time separation over threshold between aircrafts I and J in minutes
GJ = length of common approach path for the trailing arrival.

$$FV = \frac{1}{VI} - \frac{1}{VJ}$$

The input arrival-arrival separation for the Runway Capacity Model is related to the input arrival-arrival separation for the Delay Simulation Model by the equation:

SEPAR(I,J) = DLTA(I,J) + SIGAA(I,J) x F(PV)

where
SIGAA(I,J) = standard deviation of arrival-arrival separation for aircraft I and J in n.mi.
F(PV) = number of standard deviations to be protected

12. Random number seeds should be at least a four digit number; e.g., 3001.

13. A pre-processor is described in Appendix E for preparing routing data inputs. Use of this pre-processor will substantially reduce the effort required to prepare routing inputs.

14. Sample job control cards are shown in Figure 4-5. NOTE: The schedule data must be read from a previously created file NU2 on unit 8. However, the header card AIRCRAFT SCHEDULE must go with the bulk data.

15. Data which is to be entered in decimal format can be placed any where in the indicated card columns. Data which is entered in integer format must be right justified. Data which is entered in alphanumeric format must be left justified.

The following is a description of how to prepare inputs for the Delay Simulation Model Version 2. A sample input form illustrating this information is shown in Figure 4-6.

(LJ) = Left Justified
(RJ) = Right Justified
cc = Card Column

DATA TYPE	DESCRIPTION	
1 Title	cc 1-5	"TITLE"
	cc 1-80	Any Heading Data
2 Random Number Seeds	cc 1-19	"RANDOM NUMBER SEEDS" (LJ)
	cc 1-8	Number of random number seeds (RJ)
	cc 1-80	Up to 10 random number seeds, 1 every 8 cc (integer) (RJ)
3 Start & Finish Times	cc 1-19	"TIMES(START,FINISH)"
	cc 4-5	Starting hour (integer) (RJ)
	cc 7-8	Starting minute (integer) (RJ)
	cc 12-13	Finishing hour (integer) (RJ)

	cc 15-16	Finishing minute (integer) (RJ)
4 Print Options	cc 1-13	"PRINT OPTIONS"
	cc 1&2	("TR" or "FA") Option 1 Detail Aircraft Movement
	cc 9&10	("TR" or "FA") Option 2 Debugging Statements
	cc 17&18	("TR" or "FA") Option 3 Hourly Data for Each Seed
	cc 25&26	("TR" or "FA") Option 4 Warning Messages
	cc 33&34	("TR" or "FA") Option 5 aircraft nose to nose
	cc 41&42	("TR" or "FA") Option 6 queuing statistics
	cc 47&48	("TR" or "FA") Option 7. Omit printing of taxiway link data and routing data.
5 Number of Runways	cc 1-11	"RWYS NO. OF"
	cc 1-8	Number of runways, (integer) (RJ)
6 Runway Names	cc 1-9	"RWY NAMES"
	cc 1-80	Runway names, 1 every 8 cc (LJ)
7 Departure Runway End Link Numbers	cc 1-13	"RWY END LINKS"
	cc 1-32	End link numbers (integer), 1 every 8 cc (RJ) (up to 4)
8 Runway Crossing Links	cc 1-14	"RWY XING LINKS"
	cc 1-80	Any header data
	cc 1-8	Runway number (integer) (RJ)
	cc 9-16	Crossing link number

cc 25-32 Aircraft class (integer) (RJ)

cc 36&37 Arrival time at the threshold, hours (integer) (RJ)

cc 39&40 Arrival time, minutes (integer) (RJ)

cc 44&45 Departure time from the gate, hours (integer) (RJ)

cc 47&48 Departure time, minutes (integer) (RJ)

cc 49-56 Landing runway number (integer) (RJ)

cc 57-64 Departure runway number (integer) (RJ)

27 General Aviation

cc 1-16 "G/A HOLDING AREA"

cc 1-8 Number of general aviation holding areas (integer) (RJ)

cc 1-80 General aviation holding area link numbers, one every 8 card columns (integer) (RJ)

28 Processing Options

Several processing options are available:

cc 1-16 "PRINT INPUT ONLY"

This will cause a printout of all the input data in the memory at that time. This capability provides the option of data checking before running the model.

cc 1-7 "COMPUTE"

This will cause a computation or model run using the most recently input set of data. This card may be followed by any other data, which would be followed by another "COMPUTE" card. This card provides the facilities of batching different sets of data in one

program run. For example, a user could input initial data, compute, input different gate service lines, compute, input different separations and different runways, compute, etc., all in one computer run. Each "COMPUTE" card will result in all data being printed and the model run against that data.

It is recommended that initially only one random number seed be used till all coding errors have been removed from the input cards. This will minimize costs associated with debugging the inputs.

29 Completion of Run

The last input card is:

	cc 1-4	"STOP"
30 Lateness Distribution	cc 1-25	A/C "LATENESS DISTRIBUTION"
	cc 1-8	Number of pairs of Cumulative Probability & Lateness (integer) (RJ)
	cc 1-80	Pairs of Cumulative Probability & Lateness in minutes (decimal). One pair every 16 cc. Negative numbers mean the aircraft is early.

4.4 Output

The normal output of the Delay Simulation Model is the average delays, flow rates and travel times for the number random number seeds specified. The normal output includes:

Listing of input data

Flow rates (and aircraft mix)
for each hour of the run
by location on the airport

- o Runway
- o Taxiway
- o Gate

by arrival, departure and touch-and-go

Average delay per all operations
for each hour of the run
by location on the airport

- o Runway
- o Taxiway
- o Gate
- o Runway/Taxiway Crossing Points

by arrival & departure for total airfield

Total delay
for each hour of the run
for all hours of the run
by location on the airport

- o Runway
- o Taxiway
- o Gate
- o Runway/Taxiway Crossing Points

by arrival & departure for total airfield

Total travel time
for each hour of the run
by runway
by arrival and departure

Average delay per link
by taxi-in
by taxi-out

NOTE: The statistics for the first hour represent a period when the airfield goes from an unloaded to a loaded condition. The statistics for this hour should be disregarded.

The input data is listed in a predetermined sequence: i.e., it may not be listed in the order the user entered. The header cards shown in the output are different than those required by the input. The format of the output numbers is different than that required by the input. The output identifies the separations for a single runway as: runway 0 on runway 0. The output of exit selection is the cumulative probability for aircraft to use an exit instead of the input probability.

Delay is counted as each increment occurs. For example, if an aircraft starts to taxi to a gate at 8:55 and arrives at the gate at 9:05, any delays that occur before 9:00 will be part of the 8:00 to 9:00 taxi-in delays, and the delays that occur after 9:00 will be part of the 9:00 to 10:00 taxi-in delays. This method of computing average delay per operation can result in some distortion of the average delay per operation if large numbers of aircraft are being delayed in an hour. For this reason, total delay per hour is a more reliable measure of congestion than average delay per operation during an hour.

Delay per link is only shown for those links experiencing delays. Delay due to departure aircraft holding short of the runway for takeoff clearance is counted as departure runway delay.

Optional output can provide the above statistics for each random number seed. This output is displayed in a format that uses model variable names. Figure 4.3 defines the variable names used in this optional output.

The Delay Simulation Model can document the step-by-step movement of each aircraft through the airport. Any statistic available from the model can be obtained by analysis of the detail movement output. The format of the detail movement output is given in Figure 4-7.

The Delay Simulation Model will output warning messages if any of the following occur:

a) If delay on a link is less than or equal to 0 for a particular aircraft, or if the aircraft delay on a link is > 6.0 minutes.

b) If all gates for a particular aircraft size are full.

c) If two aircraft come nose-to-nose on adjacent lines.

d) If an exit number does not have an exit distance.

e) If the probabilities input for RWY EXIT SELECTION do not sum to 1.0.

The Delay Simulation Model can output arrival and departure runway queuing data if print option 6 is exercised. The model output provides:

Runway Number Departure Queue Time	Runway Number Departure Queue Departure Route Number Time	Runway Number Arrival Queue Time

From this information, the average queue during any period of time can be determined.

Print option 6 prints a message each time two aircraft moving laterally to each other come nose-to-nose at a "T" intersection. This situation is depicted in Figure 4-8. Part of the route for aircraft N (no. 15 in the schedule data) may consist of links 3 4 5 36 35. Part of the route for aircraft K (no. 53 in the schedule data) may consist of links 35 36 6 7. If it is aircraft N's time to move, the model will delay aircraft N until aircraft K has moved off link 36. The model could not "switch" the aircraft links (as would be done on one-way paths) because link 5 is not part of the route for aircraft K. The model will print the following message:

for each runway use configuration to the demand for RU1.

RU1 thru RU10	Runway use configuration number 1 thru 10.
RUNID	A header label used with title information.
TITLE	Any 20 letter name identifying the run; e.g., NATIONAL 1987 CASE 3
HOURPCT	A header label used with the proportion of daily traffic in each hour; e.g., if the daily traffic = 800 and the demand in hour HR7 = 60, the proportion for HR7 = 0.075.
HR1 thru HR24	Hour 12:00 a.m. - 12:59 a.m. through 11:00 p.m. - 11:59 p.m.
FIGNUMS	A header label used with the figure numbers given in Figure 5-1.
JPRINT	If JPRINT = 1, the model will print the total daily delay in hours for each Month-Day-Weather-Runway Use Configuration combination. If JPRINT = 0 or blank, the total daily delay will not be printed.

5.4 Input Considerations

The following factors should be considered in preparing inputs to the Annual Delay Model:

a. The sequence in which week group proportions are entered is not important. However, they must be coordinated with the annual weather distribution.

b. The input weather distribution represents the proportion of the days where that weather condition exists all day. The proportion of the days which are WE1 or WE2 should not include weather conditions which occur during very low demand periods of the day; e.g., do not include in this proportion days during which the bad weather only occurs between 10:00 p.m. and 5:00 a.m.

c. The sequence in which day group proportions are entered has no impact on annual delay. The important data is the magnitude of the numbers. The Annual Delay Model assumes that every week of each month has the same daily demand distribution.

d. The sequence in which hourly proportions are entered is very important, if demand exceeds capacity for several consecutive hours for some runway use configuration/weather combination.

e. It is recommended that only runway use configurations that occur for at least 5% of a given weather condition be considered in the annual delay analysis.

f. The Demand Profile Factor is defined as the percent of the hourly demand that occurs in the peak 15 minutes. To consider the variations of the Demand Profile Factor from hour to hour, input the average Demand Profile Factor for the busy hours of the day.

g. Touch-and-go operations do not normally occur during busy hours at commercial airports. Touch-and-go operations should be excluded from the annual operations when determining annual delay for commercial airports. If touch-and-go operations are included as part of the input for a general aviation airport, the hourly capacities should be based on the same percent touch-and-go. The Annual Delay Model treats touch-and-go operations as one arrival and one departure. If a runway use configuration consists of one runway used exclusively for touch-and-go operations and one runway for arrival and departure operations, the annual delay analysis should be done separately for each runway.

5.5 Output

The output of the Annual Delay Model consists of:

a) total annual delay in hours

b) average delay per operation in minutes

c) standard deviation of average delay per operation in minutes

d) distribution of annual delay by:

month of year
day of week
weather condition
runway use configuration

e) frequency distribution of delay per operation

The frequency distribution of annual delay per operation is computed and listed by time interval. The output format is:

Time Interval		Percent of Operations	Cumulative Percent
0.0	0.2		
0.2	0.4		
.			
.			
.			
1.8	2.0		
2.0	3.0		
.			
.			
.			
99.0	100.0		
Over 100			

WE2 = IFR
WE2 Demand = 90% of WE1 demand
RU2 = 110% of RU1
RU3 = 110% of RU1

Annual Demand Distribution

January	.087	July	.081
February	.087	August	.080
March	.082	September	.082
April	.081	October	.087
May	.080	November	.088
June	.076	December	.089

Annual Weather Distribution

	WE1	WE2		WE1	WE2
January	1.00	0.00	July	.98	.02
February	.99	.01	August	.99	.01
March	.98	.02	September	.99	.01
April	.99	.01	October	1.00	0.00
May	.98	.02	November	1.00	0.00
June	.98	.02	December	1.00	0.00

Daily Demand Distribution

Monday	.15	Friday	.15
Tuesday	.13	Saturday	.14
Wednesday	.14	Sunday	.15
Thursday	.14		

Hourly Demand Distribution

0-1	0.59	6-7	0.32	12-13	4.32	18-19	9.80
1-2	0.47	7-8	2.50	13-14	5.18	19-20	10.66
2-3	0.23	8-9	8.63	14-15	3.77	20-21	6.86
3-4	0.17	9-10	7.13	15-16	4.18	21-22	2.91
4-5	0.08	10-11	3.34	16-17	7.84	22-23	1.66
5-6	0.12	11-12	6.01	17-18	12.21	23-24	1.02

Hourly Capacity Data in Weather Condition 1

Runway Use	Runway Geometry	Figure Number	Mix Index	Hourly Capacity	Percent Utilization
1	Single RW	2-3	140	52	10
2	Parallel RW	2-4	140	72	30
3	Parallel RW	2-9	140	95	60

Hourly Capacity Data in Weather Condition 2

Runway Use	Runway Geometry	Figure Number	Mix Index	Hourly Capacity	Percent Utilization
2	Parallel RW	2-44	160	60	70
1	Single RW	2-43	160	50	30

Figure 5-3 shows the coding form for this problem with input data filled in. From the computer output shown in Figure 5-4, the total delay is found to be:

Annual Demand (Operations)	Annual Delay (Hours)
300,000	27,532
400,000	148,000

The computer run for Example 1 is contained in Figure 5-5. The total delay is found to be:

Annual Demand (Operations)	Annual Delay (Hours)
300,000	32,764
400,000	153,227

Example 2

Compute the average delay per operation for the following day.

Hourly Demand Distribution

Hour	Demand	Proportion
0-1	2	0.003
1-2	1	0.002
2-3	0	0.000
3-4	0	0.000
4-5	0	0.000
5-6	3	0.005
6-7	10	0.015
7-8	30	0.045
8-9	40	0.061
9-10	45	0.068
10-11	40	0.061
11-12	30	0.045
12-13	30	0.045
13-14	25	0.038
14-15	45	0.068
15-16	60	0.091
16-17	65	0.099
17-18	55	0.083
18-19	45	0.068
19-20	50	0.076
20-21	30	0.046
21-22	30	0.046
22-23	20	0.030
23-24	3	0.005
TOTAL	659	1.000

Use the single runway IFR data in Example 1 for all other inputs.

Figure 5-5 shows the coding form for this problem with the input data filled in. From the computer output shown in Figure 5-6 the average daily delay per operation is 7.2 minutes.

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CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

FIGURE 5-1

k r u n	i-print	jprint									
RUNID		16									
title											
ANNDEMAND		1									
ann dem											
DEMPROFILE		12									
dpf											
GROUPS		2									
ndgps	nwgps	nwecon	nrwuse								
WKPERCENT		3									
wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
WKNUMBER		4									
wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12
.	.	.	.	.	.	.	.	.	.	.	.
DPERCENT		5									
dg1	dg2	dg3	dg4	dg5	dg6	dg7					
0.	0.	0.	0.	0.	0.	0.					
DAYNUMBER		6									
dg1	dg2	dg3	dg4	dg5	dg6	dg7					
HOURPCT		11									
hr1	hr2	hr3	hr4	hr5	hr6	hr7	hr8	hr9	hr10	hr11	hr12
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
hr13	hr14	hr15	hr16	hr17	hr18	hr19	hr20	hr21	hr22	hr23	hr24
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

FIGURE 5-1

	W E A P C	T	8									
	wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12
we1	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .
we2	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .
	D E M A N	P C T	7									
	we1	we2										
	1 . 0	.										
	R W Y U S	E P C T	1 0									
	we1	we2										
ru1	0 .	0 .										
ru2	0 .	0 .										
ru3	0 .	0 .										
ru4	0 .	0 .										
ru5	0 .	0 .										
ru6	0 .	0 .										
ru7	0 .	0 .										
ru8	0 .	0 .										
ru9	0 .	0 .										
ru10	0 .	0 .										
	R W Y D E	M P C T	1 3									
	ru1	ru2	ru3	ru4	ru5	ru6	ru7	ru8	ru9	ru10		
	1 . 0	.	.	.	.	.	.	.	.	.		

122, the second number is an integer 0 through 300, the third number is a positive number less than 500, and the fourth number is between 1 and 100.

> ENTER THE FOLLOWING FOR EVERY IFR RUNWAY USAGE:
> RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX
> INDEX, HOURLY RUNWAY CAPACITY, AND PERCENT OF THE
> IFR DAYS USED

This data request is the IFR version of the preceeding data request. The input format is identical to that for VFR runway usages. The computer will go to the next data request when the "percent of the IFR days used" sums to 100.

> ENTER THE FOLLOWING FOR EVERY PVC RUNWAY USAGE:
> RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX
> INDEX, HOURLY RUNWAY CAPACITY, AND PERCENT OF THE
> PVC DAYS USED

This data request is the PVC version of the previous two data requests. It is necessary to enter data for this data request even if PVC weather does not occur (e.g., enter 1 1 1 100).

6.4 Output

Immediately after the PVC runway use configuration data is entered, the On-line Annual Delay Model will type an input summary. The input summary defines the data used to determine annual delay; this includes the actual data if built-in data is used for: monthly percent of annual operations and monthly weather distribution, daily percent of the weekly operations, the hourly percent of the daily operations. The input summary does not contain any error messages and can serve as a permanent record of inputs used for the calculation.

The output of the On-line Annual Delay Model is typed after the input summary. The output includes:

a. the total annual runway delay (in hours and minutes)

b. the average runway delay per operation (in minutes)

c. the distribution of delay per operation

The distribution of delay per operation (item c.) has been deleted from the On-line Annual Delay Model to reduce output printing time.

After the output is printed, it is possible to do parametric variations on annual opeations. The teletype will print: DO YOU WISH TO DETERMINE ANNUAL DELAY FOR ANOTHER ANNUAL DEMAND? If a "y" response is given, the terminal will make the data request ENTER ANNUAL DEMAND and calculate annual delay assuming all other inputs are identical. If any response other than "y" is given, the terminal will type the following data request:

DO YOU WISH TO PERFORM ANOTHER CALCULATION?

A "y" response to this data request will repeat the entire series of data requests for the On-line Annual Delay Model. Any other response will automatically terminate use of the On-line Annual Delay Model.

6.5 Optional uses of On-line Annual Delay Model

The On-line Annual Delay Model can be used with built-in demand distribution data to calculate:

The delay for an hour
The delay for a series of hours
The delay for a day
The delay for a week
The delay for a month
Measures of annual capacity

The following defines procedures for determining these outputs:

a. Hourly Delay. The hourly delay for a given demand per hour can be determined by:

1) Entering annual operations equal to the hourly demand x 5840. (NOTE: The On-line Annual Delay Model requires an annual demand equal to 5840 times hourly demand and the use of hourly demand distribution letter a in order to compute average delay per operation for the desired hourly demand.)

2) Entering a for the JANUARY annual demand distribution data.

3) Entering 100 100 for IFR and PVC operations as a percent of VFR.

4) Entering a for the MONDAY daily demand distribution data.

5) Entering a for the 0-1 hourly demand distribution data.

6) Entering 100 for the percent of VFR days used in the runway use configuration capacity data. Enter the appropriate runway use diagram number, mix index and hourly runway capacity.

7) Entering the same capacity and percent utilization data for IFR and PVC conditions as was used for VFR conditions.

```
OTHERS 020 1                                                              00000440
 6.018.0.040    8    0 0.0 5.03500 3.00.0    0. 100
TWO INT OR MED OR FAR PARALLEL, MIXED ON #1, ARR ON #2

BATCH CAPACITY PROGRAM, VERSION 5
TO OBTAIN 100 PERCENT ARR, AVAILABLE DEPARTURES CAPACITY IS REDUCED BY  12.7
 OPERATIONS PER HOUR

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =     68.0  ARRIVAL =     68.0  DEPARTURE =     0.0
```

```
OTHERS 020 1                                                              00000460
 6.018.0.040    8    0 0.0 5.03500 3.00.0    0.9999
TWO INT OR MED OR FAR PARALLEL, MIXED ON #1, ARR ON #2

BATCH CAPACITY PROGRAM, VERSION 5
ARRIVALS 1ST PRIORITY & DEPARTURES 2ND PRIORITY WITHOUT REGARD TO PERCENTAGE
 ARRIVALS

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =     80.7  ARRIVAL =     68.0  DEPARTURE =     12.7
```

FIGURE 3-8 (Cont.)

3.8 Command File

The On-line Runway Capacity Model Version 2 is contained in the Batch Capacity Model Version 5a. In order to use the On-line Runway Capacity Model, it is necessary to construct a command file with the following features:

1. The line length of the terminal must be set at 80 characters.

2. Unit 10 must be allocated to the terminal.

3. Unit 5 is a temporary file with a second length of 80 bytes. It must start with an end-of-file record. This can be done through the following FORTRAN program:

```
REWIND 5
END FILE 5
STOP
END
```

   The end-of-file record is used for branching purposes.

A sample command file is:

```
TERMINAL LINESIZE (80)
ALLOC DA(*) F(FT 10 F001)
ATTR DCBA BLKSIZE (1600) RECFM(FB) LRECL(80)
ALLOC DA (INPUT.DATA) F(FT05F001) NEW BL (1600) USING
  (DCBA) SP(50)
CALL EOF
CALL 'TEST.TSTLIB (OD0060C)'  capacity model is executed
FREE F(FT05001)
ALLOC DA(*) F(FTOF001)
D INPUT.DATA
FREE A(DCBA)
END
```

AIRCRAFT K= 53 AND N= 15 MET HEAD ON AT T
INTERSECTION 5 36 6. NO ACTION TAKEN. TIME=136.73

This statement does not necessarily indicate an error in the routing data, but it can be used to find errors in the routing data. For example, if the route for aircraft L occupying link 6 consisted in part of links 7 6 5 4, the situation would exist where none of the aircraft could move because the next link was occupied. None of the aircraft could "switch" links because the paths are not common. The T intersection warning message can help find this type of error in the routing data.

In reading the input data, if the model discovers that:

a. An incorrect header has been used; e.g., AL NAME instead of AIRLINE NAMES.

b. Too many data cards have been entered for a data type.

c. Too few data cards have been entered for a data type.

d. A minus sign has not been entered where required.

The model will print:

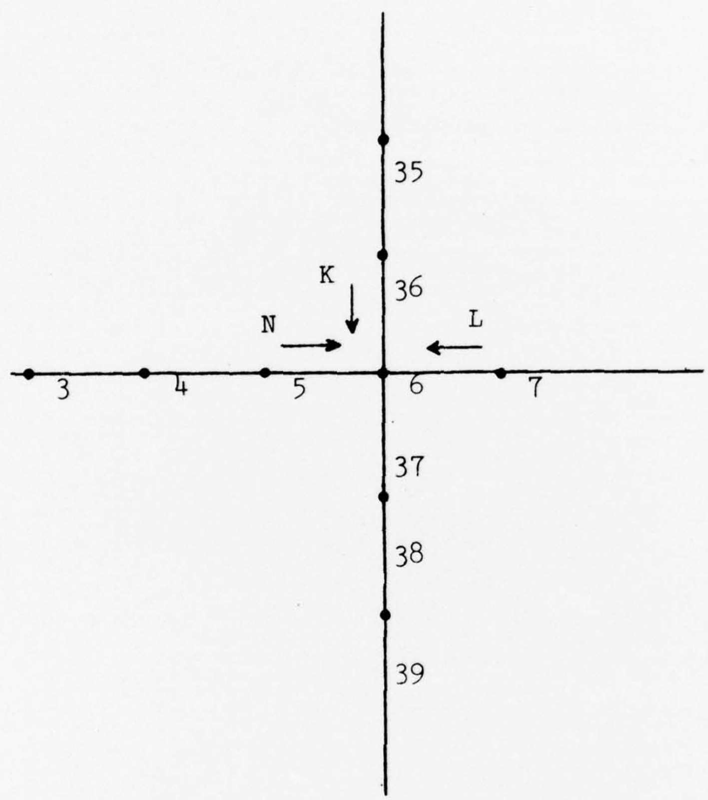
INPUT ENTRY CANNOT BE FOUND IN BRHEAD TABLE

This indicates that some data error has been made following the last printed header label.

NOTE: The BRHEAD table contains a list of all header cards.

4.5 Examples

The examples for this model are contained in Book 2 of this report.



EXAMPLE OF A "T" INTERSECTION

FIGURE 4-8

```
RUNID       16
EXAMPLE 1
ANNDEMAND    1
  300000
DEMPROFILE12
   35
GROUPS       2
    7   12     2     3
WKPERCENT   3
0.01960.02180.01850.01890.01810.01770.01830.01810.01910.01960.02050.0201
WKNUMBER     4
4.43004.00004.43004.29004.43004.29004.43004.43004.29004.43004.29004.4300
DPERCENT     5
0.15000.13000.14000.14000.15000.14000.1500
DAYNUMBER   6
    1     1     1     1     1     1     1
HOURPCT     11
0.00600.00500.00200.00200.00100.00100.00300.02500.08600.07100.03300.0600
0.04300.05200.03800.04200.07800.12200.09800.10700.06900.02900.01700.0100
WEAPCT       8
1.00000.99000.98000.99000.98000.98000.98000.99000.99001.00001.00001.0000
0.0    0.01000.02000.01000.02000.02000.02000.01000.01000.0    0.0    0.0
DEMANPCT     7
1.00000.9000
RWYUSEPCT 10
0.10000.3000
0.30000.7000
0.60000.0
RWYDEMPCT 13
1.00001.00001.0000
CAPACITY     9
 52.0 50.0
 72.0 60.0
 95.0  0.0
MIX INDEX 14
  140  160
  140  160
  140  160
FIG NUMS   15
 2- 3 2-43 2-
 2- 4 2-44 2-
 2- 9 2- 0 2-
```

```
*********************************
*    AIRPORT STUDY CONDITIONS   *
*      EXAMPLE 1                      *
*********************************
```

COMPUTER RUN FOR EXAMPLE 1

ATCH ANNUAL DELAY MODEL VERSION 1, FEB 1977

```
ONTH=  1   DAY= 1   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  882.4   DAILY DELAY (HOURS )=  527.6
ONTH=  1   DAY= 1   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  882.4   DAILY DELAY (HOURS )=  129.9
ONTH=  1   DAY= 1   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  882.4   DAILY DELAY (HOURS )=   35.2
ONTH=  1   DAY= 1   WEATHER= 2   RW CONF=  1   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=  423.3
ONTH=  1   DAY= 1   WEATHER= 2   RW CONF=  2   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=  170.1
ONTH=  1   DAY= 2   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  764.8   DAILY DELAY (HOURS )=  340.9
ONTH=  1   DAY= 2   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  764.8   DAILY DELAY (HOURS )=   58.5
ONTH=  1   DAY= 2   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  764.8   DAILY DELAY (HOURS )=   13.1
ONTH=  1   DAY= 2   WEATHER= 2   RW CONF=  1   DAILY DEMAND=  688.3   DAILY DELAY (HOURS )=  294.3
ONTH=  1   DAY= 2   WEATHER= 2   RW CONF=  2   DAILY DEMAND=  688.3   DAILY DELAY (HOURS )=   74.7
ONTH=  1   DAY= 3   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  823.6   DAILY DELAY (HOURS )=  423.5
ONTH=  1   DAY= 3   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  823.6   DAILY DELAY (HOURS )=   90.3
ONTH=  1   DAY= 3   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  823.6   DAILY DELAY (HOURS )=   20.2
ONTH=  1   DAY= 3   WEATHER= 2   RW CONF=  1   DAILY DEMAND=  741.2   DAILY DELAY (HOURS )=  344.8
ONTH=  1   DAY= 3   WEATHER= 2   RW CONF=  2   DAILY DEMAND=  741.2   DAILY DELAY (HOURS )=  109.9
ONTH=  1   DAY= 4   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  823.6   DAILY DELAY (HOURS )=  423.5
ONTH=  1   DAY= 4   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  823.6   DAILY DELAY (HOURS )=   90.3
ONTH=  1   DAY= 4   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  823.6   DAILY DELAY (HOURS )=   20.2
ONTH=  1   DAY= 4   WEATHER= 2   RW CONF=  1   DAILY DEMAND=  741.2   DAILY DELAY (HOURS )=  344.8
ONTH=  1   DAY= 4   WEATHER= 2   RW CONF=  2   DAILY DEMAND=  741.2   DAILY DELAY (HOURS )=  109.9
ONTH=  1   DAY= 5   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  882.4   DAILY DELAY (HOURS )=  527.6
ONTH=  1   DAY= 5   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  882.4   DAILY DELAY (HOURS )=  129.9
ONTH=  1   DAY= 5   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  882.4   DAILY DELAY (HOURS )=   35.2
ONTH=  1   DAY= 5   WEATHER= 2   RW CONF=  1   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=  423.3
ONTH=  1   DAY= 5   WEATHER= 2   RW CONF=  2   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=  170.1
ONTH=  1   DAY= 6   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  823.6   DAILY DELAY (HOURS )=  423.5
ONTH=  1   DAY= 6   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  823.6   DAILY DELAY (HOURS )=   90.3
ONTH=  1   DAY= 6   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  823.6   DAILY DELAY (HOURS )=   20.2
ONTH=  1   DAY= 6   WEATHER= 2   RW CONF=  1   DAILY DEMAND=  741.2   DAILY DELAY (HOURS )=  344.8
ONTH=  1   DAY= 6   WEATHER= 2   RW CONF=  2   DAILY DEMAND=  741.2   DAILY DELAY (HOURS )=  109.9
ONTH=  1   DAY= 7   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  882.4   DAILY DELAY (HOURS )=  527.6
ONTH=  1   DAY= 7   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  882.4   DAILY DELAY (HOURS )=  129.9
ONTH=  1   DAY= 7   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  882.4   DAILY DELAY (HOURS )=   35.2
ONTH=  1   DAY= 7   WEATHER= 2   RW CONF=  1   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=  423.3
ONTH=  1   DAY= 7   WEATHER= 2   RW CONF=  2   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=  170.1
ONTH=  2   DAY= 1   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  981.5   DAILY DELAY (HOURS )= 1487.4
ONTH=  2   DAY= 1   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  981.5   DAILY DELAY (HOURS )=  241.6
ONTH=  2   DAY= 1   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  981.5   DAILY DELAY (HOURS )=   67.5
ONTH=  2   DAY= 1   WEATHER= 2   RW CONF=  1   DAILY DEMAND=  883.3   DAILY DELAY (HOURS )=  654.7
ONTH=  2   DAY= 1   WEATHER= 2   RW CONF=  2   DAILY DEMAND=  883.3   DAILY DELAY (HOURS )=  269.9
ONTH=  2   DAY= 2   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  850.6   DAILY DELAY (HOURS )=  469.7
ONTH=  2   DAY= 2   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  850.6   DAILY DELAY (HOURS )=  109.4
ONTH=  2   DAY= 2   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  850.6   DAILY DELAY (HOURS )=   23.5
ONTH=  2   DAY= 2   WEATHER= 2   RW CONF=  1   DAILY DEMAND=  765.6   DAILY DELAY (HOURS )=  375.0
ONTH=  2   DAY= 2   WEATHER= 2   RW CONF=  2   DAILY DEMAND=  765.6   DAILY DELAY (HOURS )=  128.0
ONTH=  2   DAY= 3   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  916.0   DAILY DELAY (HOURS )=  631.9
ONTH=  2   DAY= 3   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  916.0   DAILY DELAY (HOURS )=  153.5
ONTH=  2   DAY= 3   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  916.0   DAILY DELAY (HOURS )=   50.6
ONTH=  2   DAY= 3   WEATHER= 2   RW CONF=  1   DAILY DEMAND=  824.4   DAILY DELAY (HOURS )=  475.7
ONTH=  2   DAY= 3   WEATHER= 2   RW CONF=  2   DAILY DEMAND=  824.4   DAILY DELAY (HOURS )=  204.8
ONTH=  2   DAY= 4   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  916.0   DAILY DELAY (HOURS )=  631.9
ONTH=  2   DAY= 4   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  916.0   DAILY DELAY (HOURS )=  153.5
ONTH=  2   DAY= 4   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  916.0   DAILY DELAY (HOURS )=   50.6
ONTH=  2   DAY= 4   WEATHER= 2   RW CONF=  1   DAILY DEMAND=  824.4   DAILY DELAY (HOURS )=  475.7
ONTH=  2   DAY= 4   WEATHER= 2   RW CONF=  2   DAILY DEMAND=  824.4   DAILY DELAY (HOURS )=  204.8
ONTH=  2   DAY= 5   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  981.5   DAILY DELAY (HOURS )= 1487.4
ONTH=  2   DAY= 5   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  981.5   DAILY DELAY (HOURS )=  241.6
ONTH=  2   DAY= 5   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  981.5   DAILY DELAY (HOURS )=   67.5
ONTH=  2   DAY= 5   WEATHER= 2   RW CONF=  1   DAILY DEMAND=  883.3   DAILY DELAY (HOURS )=  654.7
ONTH=  2   DAY= 5   WEATHER= 2   RW CONF=  2   DAILY DEMAND=  883.3   DAILY DELAY (HOURS )=  269.9
ONTH=  2   DAY= 6   WEATHER= 1   RW CONF=  1   DAILY DEMAND=  916.0   DAILY DELAY (HOURS )=  631.9
ONTH=  2   DAY= 6   WEATHER= 1   RW CONF=  2   DAILY DEMAND=  916.0   DAILY DELAY (HOURS )=  153.5
ONTH=  2   DAY= 6   WEATHER= 1   RW CONF=  3   DAILY DEMAND=  916.0   DAILY DELAY (HOURS )=   50.6
```

```
ONTH=  2   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  824.4   DAILY DELAY (HOURS )=  475.7
ONTH=  2   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  824.4   DAILY DELAY (HOURS )=  204.8
ONTH=  2   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  981.5   DAILY DELAY (HOURS )= 1487.4
ONTH=  2   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  981.5   DAILY DELAY (HOURS )=  241.6
ONTH=  2   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  981.5   DAILY DELAY (HOURS )=   67.5
ONTH=  2   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  883.3   DAILY DELAY (HOURS )=  654.7
ONTH=  2   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  883.3   DAILY DELAY (HOURS )=  269.9
ONTH=  3   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=  443.4
ONTH=  3   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=   95.5
ONTH=  3   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=   21.3
ONTH=  3   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  749.6   DAILY DELAY (HOURS )=  354.9
ONTH=  3   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  749.6   DAILY DELAY (HOURS )=  115.5
ONTH=  3   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  721.9   DAILY DELAY (HOURS )=  303.8
ONTH=  3   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  721.9   DAILY DELAY (HOURS )=   48.7
ONTH=  3   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  721.9   DAILY DELAY (HOURS )=    9.9
ONTH=  3   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  649.7   DAILY DELAY (HOURS )=  230.2
ONTH=  3   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  649.7   DAILY DELAY (HOURS )=   53.7
ONTH=  3   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=  356.1
ONTH=  3   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=   65.0
ONTH=  3   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=   14.3
ONTH=  3   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  699.6   DAILY DELAY (HOURS )=  304.5
ONTH=  3   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  699.6   DAILY DELAY (HOURS )=   81.0
ONTH=  3   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=  356.1
ONTH=  3   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=   65.0
ONTH=  3   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=   14.3
ONTH=  3   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  699.6   DAILY DELAY (HOURS )=  304.5
ONTH=  3   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  699.6   DAILY DELAY (HOURS )=   81.0
ONTH=  3   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=  443.4
ONTH=  3   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=   95.5
ONTH=  3   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=   21.3
ONTH=  3   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  749.6   DAILY DELAY (HOURS )=  354.9
ONTH=  3   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  749.6   DAILY DELAY (HOURS )=  115.5
ONTH=  3   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=  356.1
ONTH=  3   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=   65.0
ONTH=  3   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=   14.3
ONTH=  3   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  699.6   DAILY DELAY (HOURS )=  304.5
ONTH=  3   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  699.6   DAILY DELAY (HOURS )=   81.0
ONTH=  3   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=  443.4
ONTH=  3   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=   95.5
ONTH=  3   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=   21.3
ONTH=  3   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  749.6   DAILY DELAY (HOURS )=  354.9
ONTH=  3   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  749.6   DAILY DELAY (HOURS )=  115.5
ONTH=  4   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=  470.2
ONTH=  4   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=  109.6
ONTH=  4   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=   23.6
ONTH=  4   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  765.8   DAILY DELAY (HOURS )=  375.3
ONTH=  4   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  765.8   DAILY DELAY (HOURS )=  128.2
ONTH=  4   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  737.5   DAILY DELAY (HOURS )=  318.7
ONTH=  4   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  737.5   DAILY DELAY (HOURS )=   45.6
ONTH=  4   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  737.5   DAILY DELAY (HOURS )=   10.9
ONTH=  4   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  663.7   DAILY DELAY (HOURS )=  255.8
ONTH=  4   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  663.7   DAILY DELAY (HOURS )=   61.1
ONTH=  4   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=  375.6
ONTH=  4   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=   73.9
ONTH=  4   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=   17.1
ONTH=  4   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  714.8   DAILY DELAY (HOURS )=  317.0
ONTH=  4   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  714.8   DAILY DELAY (HOURS )=   92.8
ONTH=  4   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=  375.6
ONTH=  4   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=   73.9
ONTH=  4   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=   17.1
ONTH=  4   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  714.8   DAILY DELAY (HOURS )=  317.0
ONTH=  4   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  714.8   DAILY DELAY (HOURS )=   92.8
ONTH=  4   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=  470.2
ONTH=  4   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=  109.6
ONTH=  4   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=   23.6
ONTH=  4   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  765.8   DAILY DELAY (HOURS )=  375.3
ONTH=  4   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  765.8   DAILY DELAY (HOURS )=  128.2
ONTH=  4   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=  375.6
```

```
ONTH=  4   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=   73.9
ONTH=  4   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=   17.1
ONTH=  4   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  714.8   DAILY DELAY (HOURS )=  317.0
ONTH=  4   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  714.8   DAILY DELAY (HOURS )=   92.8
ONTH=  4   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=  470.2
ONTH=  4   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=  109.6
ONTH=  4   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=   23.6
ONTH=  4   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  765.8   DAILY DELAY (HOURS )=  375.3
ONTH=  4   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  765.8   DAILY DELAY (HOURS )=  128.2
ONTH=  5   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  814.9   DAILY DELAY (HOURS )=  403.4
ONTH=  5   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  814.9   DAILY DELAY (HOURS )=   85.3
ONTH=  5   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  814.9   DAILY DELAY (HOURS )=   19.2
ONTH=  5   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  733.4   DAILY DELAY (HOURS )=  335.8
ONTH=  5   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  733.4   DAILY DELAY (HOURS )=  104.7
ONTH=  5   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  706.2   DAILY DELAY (HOURS )=  272.5
ONTH=  5   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  706.2   DAILY DELAY (HOURS )=   41.9
ONTH=  5   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  706.2   DAILY DELAY (HOURS )=    8.9
ONTH=  5   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  635.6   DAILY DELAY (HOURS )=  179.3
ONTH=  5   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  635.6   DAILY DELAY (HOURS )=   46.6
ONTH=  5   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  760.6   DAILY DELAY (HOURS )=  335.9
ONTH=  5   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  760.6   DAILY DELAY (HOURS )=   56.4
ONTH=  5   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  760.6   DAILY DELAY (HOURS )=   12.7
ONTH=  5   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  684.5   DAILY DELAY (HOURS )=  291.0
ONTH=  5   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  684.5   DAILY DELAY (HOURS )=   72.5
ONTH=  5   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  760.6   DAILY DELAY (HOURS )=  335.9
ONTH=  5   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  760.6   DAILY DELAY (HOURS )=   56.4
ONTH=  5   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  760.6   DAILY DELAY (HOURS )=   12.7
ONTH=  5   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  684.5   DAILY DELAY (HOURS )=  291.0
ONTH=  5   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  684.5   DAILY DELAY (HOURS )=   72.5
ONTH=  5   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  814.9   DAILY DELAY (HOURS )=  403.4
ONTH=  5   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  814.9   DAILY DELAY (HOURS )=   85.3
ONTH=  5   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  814.9   DAILY DELAY (HOURS )=   19.2
ONTH=  5   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  733.4   DAILY DELAY (HOURS )=  335.8
ONTH=  5   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  733.4   DAILY DELAY (HOURS )=  104.7
ONTH=  5   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  760.6   DAILY DELAY (HOURS )=  335.9
ONTH=  5   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  760.6   DAILY DELAY (HOURS )=   56.4
ONTH=  5   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  760.6   DAILY DELAY (HOURS )=   12.7
ONTH=  5   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  684.5   DAILY DELAY (HOURS )=  291.0
ONTH=  5   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  684.5   DAILY DELAY (HOURS )=   72.5
ONTH=  5   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  814.9   DAILY DELAY (HOURS )=  403.4
ONTH=  5   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  814.9   DAILY DELAY (HOURS )=   85.3
ONTH=  5   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  814.9   DAILY DELAY (HOURS )=   19.2
ONTH=  5   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  733.4   DAILY DELAY (HOURS )=  335.8
ONTH=  5   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  733.4   DAILY DELAY (HOURS )=  104.7
ONTH=  6   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  796.9   DAILY DELAY (HOURS )=  379.2
ONTH=  6   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  796.9   DAILY DELAY (HOURS )=   75.3
ONTH=  6   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  796.9   DAILY DELAY (HOURS )=   17.4
ONTH=  6   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  717.2   DAILY DELAY (HOURS )=  319.4
ONTH=  6   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  717.2   DAILY DELAY (HOURS )=   94.3
ONTH=  6   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  690.6   DAILY DELAY (HOURS )=  233.6
ONTH=  6   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  690.6   DAILY DELAY (HOURS )=   35.4
ONTH=  6   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  690.6   DAILY DELAY (HOURS )=    8.0
ONTH=  6   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  621.6   DAILY DELAY (HOURS )=  161.8
ONTH=  6   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  621.6   DAILY DELAY (HOURS )=   40.0
ONTH=  6   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  743.8   DAILY DELAY (HOURS )=  325.3
ONTH=  6   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  743.8   DAILY DELAY (HOURS )=   48.5
ONTH=  6   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  743.8   DAILY DELAY (HOURS )=   11.4
ONTH=  6   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  669.4   DAILY DELAY (HOURS )=  266.2
ONTH=  6   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  669.4   DAILY DELAY (HOURS )=   64.1
ONTH=  6   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  743.8   DAILY DELAY (HOURS )=  325.3
ONTH=  6   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  743.8   DAILY DELAY (HOURS )=   48.5
ONTH=  6   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  743.8   DAILY DELAY (HOURS )=   11.4
ONTH=  6   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  669.4   DAILY DELAY (HOURS )=  266.2
ONTH=  6   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  669.4   DAILY DELAY (HOURS )=   64.1
ONTH=  6   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  796.9   DAILY DELAY (HOURS )=  379.2
ONTH=  6   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  796.9   DAILY DELAY (HOURS )=   75.3
ONTH=  6   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  796.9   DAILY DELAY (HOURS )=   17.4
ONTH=  6   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  717.2   DAILY DELAY (HOURS )=  319.4
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ONTH= 6   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 717.2   DAILY DELAY (HOURS )=  94.3
ONTH= 6   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 743.8   DAILY DELAY (HOURS )= 325.3
ONTH= 6   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 743.8   DAILY DELAY (HOURS )=  48.5
ONTH= 6   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 743.8   DAILY DELAY (HOURS )=  11.4
ONTH= 6   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 669.4   DAILY DELAY (HOURS )= 266.2
ONTH= 6   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 669.4   DAILY DELAY (HOURS )=  64.1
ONTH= 6   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 796.9   DAILY DELAY (HOURS )= 379.2
ONTH= 6   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 796.9   DAILY DELAY (HOURS )=  75.3
ONTH= 6   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 796.9   DAILY DELAY (HOURS )=  17.4
ONTH= 6   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 717.2   DAILY DELAY (HOURS )= 319.4
ONTH= 6   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 717.2   DAILY DELAY (HOURS )=  94.3
ONTH= 7   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 823.9   DAILY DELAY (HOURS )= 423.9
ONTH= 7   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 823.9   DAILY DELAY (HOURS )=  90.4
ONTH= 7   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 823.9   DAILY DELAY (HOURS )=  20.2
ONTH= 7   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 741.5   DAILY DELAY (HOURS )= 345.2
ONTH= 7   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 741.5   DAILY DELAY (HOURS )= 110.0
ONTH= 7   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 714.0   DAILY DELAY (HOURS )= 290.8
ONTH= 7   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 714.0   DAILY DELAY (HOURS )=  45.3
ONTH= 7   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 714.0   DAILY DELAY (HOURS )=   9.4
ONTH= 7   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 642.6   DAILY DELAY (HOURS )= 219.0
ONTH= 7   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 642.6   DAILY DELAY (HOURS )=  50.1
ONTH= 7   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 769.0   DAILY DELAY (HOURS )= 345.9
ONTH= 7   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 769.0   DAILY DELAY (HOURS )=  60.6
ONTH= 7   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 769.0   DAILY DELAY (HOURS )=  13.5
ONTH= 7   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 692.1   DAILY DELAY (HOURS )= 297.7
ONTH= 7   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 692.1   DAILY DELAY (HOURS )=  76.7
ONTH= 7   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 769.0   DAILY DELAY (HOURS )= 345.9
ONTH= 7   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 769.0   DAILY DELAY (HOURS )=  60.6
ONTH= 7   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 769.0   DAILY DELAY (HOURS )=  13.5
ONTH= 7   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 692.1   DAILY DELAY (HOURS )= 297.7
ONTH= 7   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 692.1   DAILY DELAY (HOURS )=  76.7
ONTH= 7   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 823.9   DAILY DELAY (HOURS )= 423.9
ONTH= 7   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 823.9   DAILY DELAY (HOURS )=  90.4
ONTH= 7   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 823.9   DAILY DELAY (HOURS )=  20.2
ONTH= 7   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 741.5   DAILY DELAY (HOURS )= 345.2
ONTH= 7   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 741.5   DAILY DELAY (HOURS )= 110.0
ONTH= 7   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 769.0   DAILY DELAY (HOURS )= 345.9
ONTH= 7   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 769.0   DAILY DELAY (HOURS )=  60.6
ONTH= 7   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 769.0   DAILY DELAY (HOURS )=  13.5
ONTH= 7   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 692.1   DAILY DELAY (HOURS )= 297.7
ONTH= 7   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 692.1   DAILY DELAY (HOURS )=  76.7
ONTH= 7   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 823.9   DAILY DELAY (HOURS )= 423.9
ONTH= 7   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 823.9   DAILY DELAY (HOURS )=  90.4
ONTH= 7   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 823.9   DAILY DELAY (HOURS )=  20.2
ONTH= 7   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 741.5   DAILY DELAY (HOURS )= 345.2
ONTH= 7   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 741.5   DAILY DELAY (HOURS )= 110.0
ONTH= 8   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )= 403.4
ONTH= 8   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )=  85.3
ONTH= 8   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )=  19.2
ONTH= 8   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 733.4   DAILY DELAY (HOURS )= 335.8
ONTH= 8   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 733.4   DAILY DELAY (HOURS )= 104.7
ONTH= 8   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 706.2   DAILY DELAY (HOURS )= 272.5
ONTH= 8   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 706.2   DAILY DELAY (HOURS )=  41.9
ONTH= 8   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 706.2   DAILY DELAY (HOURS )=   8.9
ONTH= 8   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 635.6   DAILY DELAY (HOURS )= 179.3
ONTH= 8   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 635.6   DAILY DELAY (HOURS )=  46.6
ONTH= 8   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )= 335.9
ONTH= 8   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )=  56.4
ONTH= 8   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )=  12.7
ONTH= 8   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 684.5   DAILY DELAY (HOURS )= 291.0
ONTH= 8   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 684.5   DAILY DELAY (HOURS )=  72.5
ONTH= 8   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )= 335.9
ONTH= 8   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )=  56.4
ONTH= 8   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )=  12.7
ONTH= 8   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 684.5   DAILY DELAY (HOURS )= 291.0
ONTH= 8   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 684.5   DAILY DELAY (HOURS )=  72.5
ONTH= 8   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )= 403.4
ONTH= 8   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )=  85.3
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ONTH=  8   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )=  19.2
ONTH=  8   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 733.4   DAILY DELAY (HOURS )= 335.8
ONTH=  8   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 733.4   DAILY DELAY (HOURS )= 104.7
ONTH=  8   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )= 335.9
ONTH=  8   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )=  56.4
ONTH=  8   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )=  12.7
ONTH=  8   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 684.5   DAILY DELAY (HOURS )= 291.0
ONTH=  8   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 684.5   DAILY DELAY (HOURS )=  72.5
ONTH=  8   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )= 403.4
ONTH=  8   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )=  85.3
ONTH=  8   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )=  19.2
ONTH=  8   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 733.4   DAILY DELAY (HOURS )= 335.8
ONTH=  8   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 733.4   DAILY DELAY (HOURS )= 104.7
ONTH=  9   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 859.9   DAILY DELAY (HOURS )= 484.0
ONTH=  9   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 859.9   DAILY DELAY (HOURS )= 115.0
ONTH=  9   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 859.9   DAILY DELAY (HOURS )=  24.8
ONTH=  9   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 773.9   DAILY DELAY (HOURS )= 385.8
ONTH=  9   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 773.9   DAILY DELAY (HOURS )= 150.1
ONTH=  9   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 745.3   DAILY DELAY (HOURS )= 326.9
ONTH=  9   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 745.3   DAILY DELAY (HOURS )=  49.2
ONTH=  9   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 745.3   DAILY DELAY (HOURS )=  11.5
ONTH=  9   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 670.7   DAILY DELAY (HOURS )= 268.7
ONTH=  9   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 670.7   DAILY DELAY (HOURS )=  64.9
ONTH=  9   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 802.6   DAILY DELAY (HOURS )= 386.6
ONTH=  9   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 802.6   DAILY DELAY (HOURS )=  78.4
ONTH=  9   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 802.6   DAILY DELAY (HOURS )=  17.9
ONTH=  9   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 722.3   DAILY DELAY (HOURS )= 324.5
ONTH=  9   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 722.3   DAILY DELAY (HOURS )=  97.5
ONTH=  9   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 802.6   DAILY DELAY (HOURS )= 386.6
ONTH=  9   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 802.6   DAILY DELAY (HOURS )=  78.4
ONTH=  9   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 802.6   DAILY DELAY (HOURS )=  17.9
ONTH=  9   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 722.3   DAILY DELAY (HOURS )= 324.5
ONTH=  9   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 722.3   DAILY DELAY (HOURS )=  97.5
ONTH=  9   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 859.9   DAILY DELAY (HOURS )= 484.0
ONTH=  9   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 859.9   DAILY DELAY (HOURS )= 115.0
ONTH=  9   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 859.9   DAILY DELAY (HOURS )=  24.8
ONTH=  9   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 773.9   DAILY DELAY (HOURS )= 385.8
ONTH=  9   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 773.9   DAILY DELAY (HOURS )= 150.1
ONTH=  9   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 802.6   DAILY DELAY (HOURS )= 386.6
ONTH=  9   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 802.6   DAILY DELAY (HOURS )=  78.4
ONTH=  9   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 802.6   DAILY DELAY (HOURS )=  17.9
ONTH=  9   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 722.3   DAILY DELAY (HOURS )= 324.5
ONTH=  9   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 722.3   DAILY DELAY (HOURS )=  97.5
ONTH=  9   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 859.9   DAILY DELAY (HOURS )= 484.0
ONTH=  9   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 859.9   DAILY DELAY (HOURS )= 115.0
ONTH=  9   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 859.9   DAILY DELAY (HOURS )=  24.8
ONTH=  9   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 773.9   DAILY DELAY (HOURS )= 385.8
ONTH=  9   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 773.9   DAILY DELAY (HOURS )= 150.1
ONTH= 10   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 882.4   DAILY DELAY (HOURS )= 527.6
ONTH= 10   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 882.4   DAILY DELAY (HOURS )= 129.9
ONTH= 10   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 882.4   DAILY DELAY (HOURS )=  35.2
ONTH= 10   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 794.2   DAILY DELAY (HOURS )= 423.3
ONTH= 10   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 794.2   DAILY DELAY (HOURS )= 170.1
ONTH= 10   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 764.8   DAILY DELAY (HOURS )= 340.9
ONTH= 10   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 764.8   DAILY DELAY (HOURS )=  58.5
ONTH= 10   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 764.8   DAILY DELAY (HOURS )=  13.1
ONTH= 10   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 688.3   DAILY DELAY (HOURS )= 294.3
ONTH= 10   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 688.3   DAILY DELAY (HOURS )=  74.7
ONTH= 10   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 823.6   DAILY DELAY (HOURS )= 423.5
ONTH= 10   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 823.6   DAILY DELAY (HOURS )=  90.3
ONTH= 10   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 823.6   DAILY DELAY (HOURS )=  20.2
ONTH= 10   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 741.2   DAILY DELAY (HOURS )= 344.8
ONTH= 10   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 741.2   DAILY DELAY (HOURS )= 109.9
ONTH= 10   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 823.6   DAILY DELAY (HOURS )= 423.5
ONTH= 10   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 823.6   DAILY DELAY (HOURS )=  90.3
ONTH= 10   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 823.6   DAILY DELAY (HOURS )=  20.2
ONTH= 10   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 741.2   DAILY DELAY (HOURS )= 344.8
ONTH= 10   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 741.2   DAILY DELAY (HOURS )= 109.9
```

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ONTH= 10   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 882.4   DAILY DELAY (HOURS )=  527.6
ONTH= 10   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 882.4   DAILY DELAY (HOURS )=  129.9
ONTH= 10   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 882.4   DAILY DELAY (HOURS )=   35.2
ONTH= 10   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 794.2   DAILY DELAY (HOURS )=  423.3
ONTH= 10   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 794.2   DAILY DELAY (HOURS )=  170.1
ONTH= 10   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 823.6   DAILY DELAY (HOURS )=  423.5
ONTH= 10   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 823.6   DAILY DELAY (HOURS )=   90.3
ONTH= 10   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 823.6   DAILY DELAY (HOURS )=   20.2
ONTH= 10   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 741.2   DAILY DELAY (HOURS )=  344.8
ONTH= 10   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 741.2   DAILY DELAY (HOURS )=  109.9
ONTH= 10   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 882.4   DAILY DELAY (HOURS )=  527.6
ONTH= 10   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 882.4   DAILY DELAY (HOURS )=  129.9
ONTH= 10   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 882.4   DAILY DELAY (HOURS )=   35.2
ONTH= 10   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 794.2   DAILY DELAY (HOURS )=  423.3
ONTH= 10   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 794.2   DAILY DELAY (HOURS )=  170.1
ONTH= 11   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 922.9   DAILY DELAY (HOURS )=  648.6
ONTH= 11   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 922.9   DAILY DELAY (HOURS )=  160.3
ONTH= 11   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 922.9   DAILY DELAY (HOURS )=   53.7
ONTH= 11   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 830.7   DAILY DELAY (HOURS )=  484.9
ONTH= 11   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 830.7   DAILY DELAY (HOURS )=  211.6
ONTH= 11   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 799.9   DAILY DELAY (HOURS )=  383.1
ONTH= 11   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 799.9   DAILY DELAY (HOURS )=   77.0
ONTH= 11   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 799.9   DAILY DELAY (HOURS )=   17.7
ONTH= 11   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 719.9   DAILY DELAY (HOURS )=  322.1
ONTH= 11   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 719.9   DAILY DELAY (HOURS )=   96.0
ONTH= 11   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 861.4   DAILY DELAY (HOURS )=  486.3
ONTH= 11   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 861.4   DAILY DELAY (HOURS )=  115.9
ONTH= 11   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 861.4   DAILY DELAY (HOURS )=   25.0
ONTH= 11   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 775.3   DAILY DELAY (HOURS )=  387.6
ONTH= 11   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 775.3   DAILY DELAY (HOURS )=  151.4
ONTH= 11   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 861.4   DAILY DELAY (HOURS )=  486.3
ONTH= 11   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 861.4   DAILY DELAY (HOURS )=  115.9
ONTH= 11   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 861.4   DAILY DELAY (HOURS )=   25.0
ONTH= 11   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 775.3   DAILY DELAY (HOURS )=  387.6
ONTH= 11   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 775.3   DAILY DELAY (HOURS )=  151.4
ONTH= 11   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 922.9   DAILY DELAY (HOURS )=  648.6
ONTH= 11   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 922.9   DAILY DELAY (HOURS )=  160.3
ONTH= 11   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 922.9   DAILY DELAY (HOURS )=   53.7
ONTH= 11   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 830.7   DAILY DELAY (HOURS )=  484.9
ONTH= 11   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 830.7   DAILY DELAY (HOURS )=  211.6
ONTH= 11   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 861.4   DAILY DELAY (HOURS )=  486.3
ONTH= 11   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 861.4   DAILY DELAY (HOURS )=  115.9
ONTH= 11   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 861.4   DAILY DELAY (HOURS )=   25.0
ONTH= 11   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 775.3   DAILY DELAY (HOURS )=  387.6
ONTH= 11   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 775.3   DAILY DELAY (HOURS )=  151.4
ONTH= 11   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 922.9   DAILY DELAY (HOURS )=  648.6
ONTH= 11   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 922.9   DAILY DELAY (HOURS )=  160.3
ONTH= 11   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 922.9   DAILY DELAY (HOURS )=   53.7
ONTH= 11   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 830.7   DAILY DELAY (HOURS )=  484.9
ONTH= 11   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 830.7   DAILY DELAY (HOURS )=  211.6
ONTH= 12   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 904.9   DAILY DELAY (HOURS )=  605.0
ONTH= 12   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 904.9   DAILY DELAY (HOURS )=  145.5
ONTH= 12   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 904.9   DAILY DELAY (HOURS )=   46.2
ONTH= 12   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 814.4   DAILY DELAY (HOURS )=  460.9
ONTH= 12   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 814.4   DAILY DELAY (HOURS )=  194.1
ONTH= 12   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 784.3   DAILY DELAY (HOURS )=  364.6
ONTH= 12   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 784.3   DAILY DELAY (HOURS )=   68.6
ONTH= 12   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 784.3   DAILY DELAY (HOURS )=   16.2
ONTH= 12   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 705.9   DAILY DELAY (HOURS )=  309.6
ONTH= 12   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 705.9   DAILY DELAY (HOURS )=   84.5
ONTH= 12   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 844.6   DAILY DELAY (HOURS )=  460.6
ONTH= 12   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 844.6   DAILY DELAY (HOURS )=  102.3
ONTH= 12   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 844.6   DAILY DELAY (HOURS )=   22.7
ONTH= 12   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 760.1   DAILY DELAY (HOURS )=  368.1
ONTH= 12   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 760.1   DAILY DELAY (HOURS )=  122.8
ONTH= 12   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 844.6   DAILY DELAY (HOURS )=  460.6
ONTH= 12   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 844.6   DAILY DELAY (HOURS )=  102.3
ONTH= 12   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 844.6   DAILY DELAY (HOURS )=   22.7
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ONTH= 12    DAY= 4    WEATHER= 2    RW CONF= 1    DAILY DEMAND=  760.1    DAILY DELAY (HOURS  )=   368.1
ONTH= 12    DAY= 4    WEATHER= 2    RW CONF= 2    DAILY DEMAND=  760.1    DAILY DELAY (HOURS  )=   122.8
ONTH= 12    DAY= 5    WEATHER= 1    RW CONF= 1    DAILY DEMAND=  904.9    DAILY DELAY (HOURS  )=   605.0
ONTH= 12    DAY= 5    WEATHER= 1    RW CONF= 2    DAILY DEMAND=  904.9    DAILY DELAY (HOURS  )=   145.5
ONTH= 12    DAY= 5    WEATHER= 1    RW CONF= 3    DAILY DEMAND=  904.9    DAILY DELAY (HOURS  )=    46.2
ONTH= 12    DAY= 5    WEATHER= 2    RW CONF= 1    DAILY DEMAND=  814.4    DAILY DELAY (HOURS  )=   460.9
ONTH= 12    DAY= 5    WEATHER= 2    RW CONF= 2    DAILY DEMAND=  814.4    DAILY DELAY (HOURS  )=   194.1
ONTH= 12    DAY= 6    WEATHER= 1    RW CONF= 1    DAILY DEMAND=  844.6    DAILY DELAY (HOURS  )=   460.6
ONTH= 12    DAY= 6    WEATHER= 1    RW CONF= 2    DAILY DEMAND=  844.6    DAILY DELAY (HOURS  )=   102.3
ONTH= 12    DAY= 6    WEATHER= 1    RW CONF= 3    DAILY DEMAND=  844.6    DAILY DELAY (HOURS  )=    22.7
ONTH= 12    DAY= 6    WEATHER= 2    RW CONF= 1    DAILY DEMAND=  760.1    DAILY DELAY (HOURS  )=   368.1
ONTH= 12    DAY= 6    WEATHER= 2    RW CONF= 2    DAILY DEMAND=  760.1    DAILY DELAY (HOURS  )=   122.8
ONTH= 12    DAY= 7    WEATHER= 1    RW CONF= 1    DAILY DEMAND=  904.9    DAILY DELAY (HOURS  )=   605.0
ONTH= 12    DAY= 7    WEATHER= 1    RW CONF= 2    DAILY DEMAND=  904.9    DAILY DELAY (HOURS  )=   145.5
ONTH= 12    DAY= 7    WEATHER= 1    RW CONF= 3    DAILY DEMAND=  904.9    DAILY DELAY (HOURS  )=    46.2
ONTH= 12    DAY= 7    WEATHER= 2    RW CONF= 1    DAILY DEMAND=  814.4    DAILY DELAY (HOURS  )=   460.9
ONTH= 12    DAY= 7    WEATHER= 2    RW CONF= 2    DAILY DEMAND=  814.4    DAILY DELAY (HOURS  )=   194.1

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ANNUAL SUMMARY

AVERAGE DELAY (MINUTES) AT LEAST	LESS THAN	DISTRIBUTION PERCENT OCCURRENCE	
0.0	0.2	9.001	9.0
0.2	0.4	13.318	22.3
0.4	0.6	11.583	33.9
0.6	0.8	7.700	41.6
0.8	1.0	4.420	46.0
1.0	1.2	2.409	48.4
1.2	1.4	2.448	50.9
1.4	1.6	1.225	52.1
1.6	1.8	1.032	53.1
1.8	2.0	1.371	54.5
2.0	3.0	5.490	60.0
3.0	4.0	9.661	69.7
4.0	5.0	2.908	72.6
5.0	6.0	2.056	74.6
6.0	7.0	1.267	75.9
7.0	8.0	3.034	78.9
8.0	9.0	2.329	81.3
9.0	10.0	0.816	82.1
10.0	11.0	0.683	82.8
11.0	12.0	1.682	84.4
12.0	13.0	1.003	85.4
13.0	14.0	1.535	87.0
14.0	15.0	1.112	88.1
15.0	16.0	1.402	89.5
16.0	17.0	0.520	90.0
17.0	18.0	1.157	91.2
18.0	19.0	0.024	91.2
19.0	20.0	0.830	92.0
20.0	21.0	1.142	93.2
24.0	25.0	0.168	93.3
25.0	26.0	0.747	94.1
26.0	27.0	0.154	94.2
27.0	28.0	0.169	94.4
31.0	32.0	0.016	94.4
32.0	33.0	0.002	94.4
34.0	35.0	0.005	94.4
35.0	36.0	0.003	94.4
36.0	37.0	0.045	94.5
38.0	39.0	0.003	94.5
41.0	42.0	0.093	94.6
42.0	43.0	0.001	94.6
43.0	44.0	0.057	94.6
45.0	46.0	0.071	94.7
46.0	47.0	0.582	95.3
47.0	48.0	0.294	95.6
48.0	49.0	0.252	95.8
49.0	50.0	0.182	96.0
50.0	51.0	0.412	96.4
51.0	52.0	0.377	96.8
52.0	53.0	0.574	97.4
53.0	54.0	0.396	97.8
54.0	55.0	0.264	98.0
55.0	56.0	0.405	98.4
56.0	57.0	0.442	98.9
58.0	59.0	0.446	99.3
59.0	60.0	0.241	99.6
95.0	96.0	0.441	100.0

MEAN OF AVERAGE DELAY = 6.55
STANDARD DEVIATION = 8.07

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ANNUAL DELAY	=	32764.0	HOURS
ANNUAL DEMAND	=	300000	OPERATIONS
AVERAGE DELAY	=	6.55	MINUTES-AIRCRAFT

MONTHLY SUMMARY OF ANNUAL DELAY

MONTH	ANNUAL DELAY HOURS
1	2847.2
2	5228.0
3	2265.4
4	2362.5
5	2053.1
6	1818.0
7	2161.0
8	2027.8
9	2461.2
10	2847.2
11	3443.7
12	3249.5

SUMMARY OF ANNUAL DELAY BY DAY OF WEEK

DAY	ANNUAL DELAY HOURS
1	5862.1
2	2998.5
3	4059.9
4	4059.9
5	5862.1
6	4059.9
7	5862.1

SUMMARY OF ANNUAL DELAY BY WEATHER CONDITION

WEATHER	ANNUAL DELAY HOURS
1	32158.9
2	605.3

SUMMARY OF ANNUAL DELAY BY WEATHER AND RW CONF

WEATHER	RW CONF	ANNUAL DELAY HOURS
1	1	16659.4
1	2	10329.7
1	3	5169.9
2	1	353.4
2	2	252.0
2	3	0.0

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RUNID       16
EXAMPLE 1
ANNDEMAND   1
  400000
DEMPROFILE12
  35
GROUPS      2
    7   12    2    3
WKPERCENT   3
0.01960.02180.01850.01890.01810.01770.01830.01810.01910.01960.02050.0201
WKNUMBER    4
4.43004.00004.43004.29004.43004.29004.43004.43004.29004.43004.29004.4300
DPERCENT    5
0.15000.13000.14000.14000.15000.14000.1500
DAYNUMBER   6
    1    1    1    1    1    1    1
HOURPCT    11
0.00600.00500.00200.00200.00100.00100.00300.02500.08600.07100.03300.0600
0.04300.05200.03800.04200.07800.12200.09800.10700.06900.02900.01700.0100
WEAPCT      8
1.00000.99000.98000.99000.98000.98000.98000.99000.99001.00001.00001.0000
0.0    0.01000.02000.01000.02000.02000.02000.01000.01000.0    0.0    0.0
DEMANPCT    7
1.00000.9000
RWYUSEPCT 10
0.10000.3000
0.30000.7000
0.60000.0
RWYDEMPCT 13
1.00001.00001.0000
CAPACITY    9
 52.0 50.0
 72.0 60.0
 95.0  0.0
MIX INDEX 14
  140  160
  140  160
  140  160
FIG NUMS   15
 2- 3 2-43 2-
 2- 4 2-44 2-
 2- 9 2- 0 2-
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*   AIRPORT STUDY CONDITIONS   *
*      EXAMPLE 1                     *
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ANNUAL SUMMARY

AVERAGE DELAY (MINUTES) AT LEAST	AVERAGE DELAY (MINUTES) LESS THAN	DISTRIBUTION PERCENT OCCURRENCE	
0.0	0.2	4.207	4.2
0.2	0.4	7.905	12.1
0.4	0.6	4.616	16.7
0.6	0.8	3.890	20.6
0.8	1.0	2.933	23.6
1.0	1.2	1.902	25.5
1.2	1.4	0.932	26.4
1.4	1.6	1.392	27.8
1.6	1.8	1.199	29.0
1.8	2.0	0.559	29.5
2.0	3.0	4.668	34.2
3.0	4.0	4.184	38.4
4.0	5.0	2.638	41.0
5.0	6.0	1.356	42.4
6.0	7.0	0.692	43.1
7.0	8.0	1.228	44.3
8.0	9.0	0.671	45.0
9.0	10.0	2.463	47.4
10.0	11.0	3.349	50.8
11.0	12.0	0.547	51.3
12.0	13.0	0.809	52.1
13.0	14.0	0.280	52.4
14.0	15.0	2.036	54.5
15.0	16.0	1.489	55.9
16.0	17.0	0.466	56.4
18.0	19.0	1.789	58.2
19.0	20.0	2.763	61.0
20.0	21.0	1.036	62.0
21.0	22.0	0.541	62.5
22.0	23.0	1.427	64.0
23.0	24.0	1.435	65.4
25.0	26.0	2.177	67.6
26.0	27.0	0.604	68.2
27.0	28.0	0.033	68.2
28.0	29.0	3.193	71.4
29.0	30.0	0.834	72.2
30.0	31.0	0.686	72.9
31.0	32.0	1.842	74.8
32.0	33.0	3.252	78.0
33.0	34.0	0.567	78.6
34.0	35.0	1.116	79.7
35.0	36.0	0.076	79.8
36.0	37.0	1.745	81.5
37.0	38.0	0.601	82.1
39.0	40.0	0.617	82.7
40.0	41.0	0.783	83.5
42.0	43.0	0.007	83.5
44.0	45.0	1.468	85.0
49.0	50.0	1.261	86.3
50.0	51.0	0.036	86.3
51.0	52.0	1.376	87.7
52.0	53.0	0.714	88.4
53.0	54.0	1.355	89.7
55.0	56.0	0.002	89.7
56.0	57.0	0.751	90.5
57.0	58.0	0.005	90.5
59.0	60.0	0.054	90.6
60.0	61.0	0.093	90.6
61.0	62.0	0.070	90.7
62.0	63.0	0.058	90.8
83.0	84.0	0.028	90.8
91.0	92.0	0.009	90.8
93.0	94.0	0.611	91.4
94.0	95.0	0.496	91.9
95.0	96.0	0.108	92.0
96.0	97.0	0.580	92.6
97.0	98.0	0.127	92.7
98.0	99.0	0.105	92.8
MORE THAN	100.0	7.161	

MEAN OF AVERAGE DELAY = 22.98
STANDARD DEVIATION = 14.25

ANNUAL DELAY	=	153227.0	HOURS
ANNUAL DEMAND	=	400000	OPERATIONS
AVERAGE DELAY	=	22.98	MINUTES-AIRCRAFT

MONTHLY SUMMARY OF ANNUAL DELAY

MONTH	ANNUAL DELAY HOURS
1	14088.9
2	19665.5
3	10680.7
4	11594.5
5	9759.4
6	8713.6
7	10195.7
8	9679.5
9	12467.3
10	14088.9
11	16675.8
12	15622.9

SUMMARY OF ANNUAL DELAY BY DAY OF WEEK

DAY	ANNUAL DELAY HOURS
1	26811.1
2	13474.4
3	19774.9
4	19774.9
5	26811.1
6	19774.9
7	26811.1

SUMMARY OF ANNUAL DELAY BY WEATHER CONDITION

WEATHER	ANNUAL DELAY HOURS
1	150793.2
2	2435.3

SUMMARY OF ANNUAL DELAY BY WEATHER AND RW CONF

WEATHER	RW CONF	ANNUAL DELAY HOURS
1	1	65702.1
1	2	45432.7
1	3	39662.5
2	1	1286.5
2	2	1148.8
2	3	0.0